Flood Hazard Mitigation Plan for Colorado

June 2004

Prepared Pursuant to
Disaster Mitigation Act 2000 & Section 409, PL 93-288

Prepared for
Colorado Water Conservation Board
Department of Natural Resources

in Cooperation with
The Department of Local Affairs
Division of Local Government
Office of Emergency Management

PREFACE

The State of Colorado, its political subdivisions, and our residents are confronted daily with the possibility of flooding and related hazards. Floods have the potential for inflicting tremendous damages with significant losses of life and property, as well as posing a threat to the health, safety, and welfare of Colorado's residents.

Current growth and population migration require a heightened awareness that the impact of flooding likely will increase over time. Mitigation begins with effective hazard assessments and comprehensive disaster preparedness programs. Mitigation builds upon the foundation of disaster preparedness by implementing strategies that are part of an overall plan to effectively reduce losses from disasters.

The Colorado Office of Emergency Management (OEM) is designated by law as the coordinating agency for disaster preparedness, response, recovery, and mitigation. The Colorado Water Conservation Board (CWCB) is the lead state agency for flood mitigation. These two offices assist other state agencies, local governments, Native American Tribes, and the private sector in addressing hazard identification and mitigation actions.

This flood mitigation plan represents a commitment to mitigate potential losses and damages by isolating the primary causes and recommending courses of action. The intent of the information, ideas and recommendations contained herein is to make a concerted effort to reduce or limit flooding impact on the people of Colorado.

This plan reflects the state's priorities for flood hazard mitigation. These priorities were developed through a private/local/state/federal team process. In order to implement this plan, a number of agencies, entities, and others need to work together to successfully mitigate damages caused by flooding. The goals and objectives outlined in the plan and within the appendices support this effort. Accomplishments can be realized only by joint efforts, dedication, and commitment to mitigation.

This plan was prepared in accordance with the Disaster Mitigation Act of 2000, 44 CFR Parts 201 and 206, Interim Final Rule.

CHAPTER 1 - INTRODUCTION

1.0 Introduction

Purpose

In addition to fulfilling the legal obligation under the Stafford Act, this mitigation plan serves to:

- Recognize and describe flood hazards and their impacts upon the state.
- Document existing federal, state, and local government programs that relate to flood hazard mitigation.
- Identify and discuss critical issues which, if resolved, would enhance mitigation efforts.
- Identify and establish mitigation goals, objectives, and priorities for governmental actions to reduce flood damages.
- Offer mitigation strategies and measures for the state and local government jurisdictions to use in their planning efforts.
- Guide the State of Colorado and its local jurisdictions in taking action as may be reasonably expected to reduce flood damages.

Scope

The scope of the plan is statewide. All streams and their floodplains in Colorado have the potential to flood and cause damages, regardless of the cause. Both short-term and long-term opportunities for flood hazard mitigation are considered. The human encroachment of these floodplains increase the hazard and related damages.

The 2004 Colorado Flood Hazard Mitigation Plan is the cornerstone for establishing and guiding a statewide effort to reduce or eliminate the impact on life, property, and the environment from the flood hazard. The costs of responding to and recovering from repetitive flooding increases with each event. However, it is possible to break the cycle of recurring damage by evaluating the root cause and choosing a logical and realistic course of action from among potential alternative solutions to eliminate or reduce either the cause or its impact.

The implementation of mitigation measures is challenging due to additional costs and assuring cost effectiveness of the measures. Mitigation measures can be difficult to initiate because of social/economic and/or political oppositions. Perceptions of benefit vs. threat diminish greatly as an event fades from thought. However, mitigation successes can be accomplished by preparing accurate assessment information regarding hazards and maintaining strong leadership and a commitment for positive change.

Government officials at all levels must understand that without proactive mitigation by all applicable government agencies, the costs associated with a natural disaster will increase. If no mitigation is undertaken, the accumulated costs of future disasters will far exceed the cost of mitigation efforts applied now.

The Flood Hazard Mitigation Plan is not a manual on what state agencies should do when the next flood or dam break occurs. Such response procedures are covered in the Colorado State Emergency Operations Plan. It is a guide for implementing mitigation measures.

Authority & Responsibilities

Federal

The requirement for state governments to prepare a Flood Hazard Mitigation Plan following a Presidential Disaster Declaration is stated in Section 409 of Public Law 93-288, Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) as amended by Public Law 100-707, 42 U.S.C. 5121 et seq, Disaster Mitigation Act 2000 and the Hazard Mitigation and Relocation Assistance Act of 1993. It establishes the prerequisites for state receipt of federal disaster assistance. Additional authority is derived from the following:

- Presidential Executive Order 11988, Floodplain Management
- Presidential Executive Order 11990, Protection of Wetlands
- FEMA Regulation, 44 CFR, Part 13, Administrative Requirements
- FEMA Regulations, 44 CFR, Part 17, Subpart F, Drug-Free Work Place
- FEMA Regulations, 44 CFR, Part 206, Subparts M & N
- FEMA - 1186-DR-CO Hazard Mitigation Team Report - October 1997
- FEMA - 1276-DR-CO Hazard Mitigation Team Report - July 30, 1999

State

Presidentially declared disasters include a stipulation that the state must initiate the mitigation process. This condition is required by Section 409 of the Stafford Act (as amended) and is also stated in the FEMA-State Agreements. The governor, through his executive power, directs specific agencies to participate in post-disaster mitigation activities.

State Mitigation Planning

The first Flood Hazard Mitigation Plan was prepared as a result of the presidential declaration of disaster for Larimer County on July 22, 1982 (FEMA-665-DR-CO). The following are additions and revisions to the original plan:

- Status report No. 1 prepared December 1983.
- Second review prepared January 1985 following declaration of 10 western slope counties as a major disaster area eligible for public assistance on July 27, 1984 (FEMA-719-DR-CO).
- In 1998, the Colorado Flood Hazard Mitigation Plan was updated due to declaration DR-1186-CO.
- In 1999, the Colorado Flood Hazard Mitigation Plan was updated due to declaration DR-1276-CO.
- In 2004, this update is due to the Disaster Mitigation Act 2000.

Local Government

Local governments play an essential role in implementing effective mitigation, both before and after disaster events. Recommendations on alleviating or eliminating a repetitive problem often focus on local assessment as to the cause of damage and depend on a local applicant for implementation.

Both OEM and the Colorado Water Conservation Board (CWCB) have suggested that communities prepare a flood hazard mitigation plan for their jurisdictions. A carefully drafted plan can be an extremely valuable resource to formulate annual work programs, budgets, and policy positions. Some State and Federal grant funding for mitigation assistance eligibility depends on the completion and approval of hazard mitigation plans.

CHAPTER 2 – HAZARD IDENTIFICATION AND EVALUATION

2.0 Hazard Identification and Evaluation

People and Hazards

The relationship between flood hazards and population identifies patterns of risk. Such relationships are not new to Colorado. Flooding has occurred here long before people settled in high-risk areas. Risk grows from the increasingly close association between natural phenomena and a growing population.

People become vulnerable to hazards when they choose (knowingly or unknowingly) to live near the areas where these extreme events occur. Vulnerability is also related to preparedness. People who prepare for the occurrence of an extreme event are less vulnerable to it than those who do not. The vulnerability of Colorado's population is rooted in a relationship between the occurrences of extreme events, the proximity of people to these occurrences, and the degree to which these people are prepared to cope with these extremes of nature.

Today, flood prone areas have been identified in 268 cities and towns and in all of the 64 counties in Colorado. Using information supplied from local units of government, there are estimated to be approximately 250,000 people now living in Colorado's floodplains. The Colorado Water Conservation Board (CWCB) estimates that approximately 65,000 homes and 15,000 commercial and industrial business structures are located in Colorado's floodplains. Designation of floodplains in Colorado for floodplain management activities is at the 100-year flood event. Cumulative flood losses from the turn of the century to 2003 from the state's most damaging floods are over $5 billion (2003 dollars).

Types of Hazards

Floods

A flood is a general and temporary condition of partial or complete inundation of normally dry land areas from 1) the overflow of stream banks, 2) the unusual and rapid accumulation or runoff of surface waters from any source, or 3) mudflows or the sudden collapse of shoreline land. Flooding results when the flow of water is greater than the normal carrying capacity of the stream channel. Rate of rise, magnitude (or peak discharge), duration, and frequency of floods are a function of specific physiographic characteristics. Generally the rise in water surface elevation is quite rapid on small (and steep gradient) streams and slow in large (and flat sloped) streams. The causes of floods relate directly to the accumulation of water from precipitation, rapid snowmelt, or the failure of manmade structures, such as dams or levees. Floods caused by precipitation are further classified as coming from:

- ***Rain in a general storm system***
- ***Rain in a localized intense thunderstorm***
- ***Melting snow***
- ***Rain on melting snow***
- ***Ice jams***

Rainfall and melting snow in Colorado's seven river basins feed four major river systems of the western United States. These river systems are the Missouri, Arkansas, Rio Grande, and Colorado river basins. These basins encompass many small streams and rivers as shown in ***Figure 2.1***. **(insert basin map)**

Originating in Park County, the South Platte River has drainage tributaries from north-central to northeastern Colorado. The river basin has a drainage area of about 24,300 square miles and is located in three states: Colorado (79 percent of the basin); Nebraska (15 percent of the basin); and Wyoming (6 percent of the basin).

The basin has a continental climate modified by topography, in which there are large temperature ranges and irregular seasonal and annual precipitation. Mean temperatures increase from west to east and on the plains from north to south. Areas along the Continental Divide average 30 inches or more of precipitation annually, which includes snowfall in excess of 300 inches. In contrast, annual precipitation on the plains east of Denver, Colorado, and in the South Park area in the southwest part of the basin ranges from 5 to 7 inches. Most of the precipitation on the plains occurs as rain, which falls between April and September.

Rangeland is present across all areas of the basin except over the high mountain forests. Agricultural land is restricted mostly to the plains. Urban or built-up land is present primarily along the Front Range urban corridor in Colorado.

Phillips County and parts of Lincoln and Elbert Counties have drainage tributaries to the Republican River. The Republican River is, in turn, a tributary to the Kansas River in Kansas. The Republican River Basin in Colorado consists primarily of rangeland with some farming and ranching communities scattered throughout the basin.

The Arkansas River Basin is very similar to the South Platte River Basin in topography, geology, and hydrology. Annual mean temperatures are slightly higher than the Platte River Basin. Annual rainfall amounts average between 7 and 15 inches, except in the mountainous areas of the basin. Land use is similar as well and consists mainly of agriculture.

The Arkansas River headwaters are located in Lake County and the drainage basin consists of the southeastern quarter of the state.

The southern portion of Baca County has drainage tributaries to the Cimmaron River. The Cimmaron River flows from Colorado into Kansas and then into Oklahoma where it ultimately joins the Arkansas River in Tulsa. The Cimmaron River Basin is similar in topography and climate to the Arkansas River Basin.

Precipitation in each basin is related to the seasons and two major sources of moisture. Summer showers and thunderstorms that occur from May through September primarily are caused by moisture from the Gulf of Mexico or the Pacific Ocean. During the fall, occasional general rainstorms and thunderstorms occur from wet and warm cyclonic air masses that move in from the southern Pacific Ocean. Winter and spring rain and snow storms are generally a result of moist air masses which originate in the cooler northern Pacific Ocean and move inland across the Pacific Northwest.

Floods caused by failure of man-made structures are a result of:

- ***Hydrologic deficiencies***
- ***Structural deficiencies***
- ***Improper Operation or Sabotage*** *(1 case in CO)*

Each of these causes results in floods that have distinct characteristics relative to flow rate, rate of rise, volume, duration, and flood season.

General Rain Floods

General rain floods can result from moderate to heavy rainfall occurring over a wide geographic area lasting several days. They are characterized by a slow steady rise in stream stage and a peak flood of long duration. As various minor streams empty into larger and larger channels, the peak discharge on the mainstream channel may progress upstream or downstream (or remain stationary) over a considerable length of river. General rain floods can result in considerably large volumes of water. The general rain flood season is historically from the beginning of May through October. Because the rate of rise is slow and the time available for warning is great, few lives are usually lost, but millions of dollars in valuable public and private property are at risk.

The October 5, 1911 floods in Pagosa Springs and Durango were a result of a general rain system over tributaries of the San Juan River Basin in southwestern Colorado. The June 3, 1921 flood in Pueblo was a result of a general rain system in the Upper Arkansas River Basin. The damaging floods of June 1965 in the Denver-metro area were a result of heavy to torrential rainfall over large portions of the South Platte River Basin that lasted several days.

Thunderstorm Floods

Damaging thunderstorm floods are caused by intense rain over basins of relatively small area. They are characterized by a sudden rise in stream level, short duration, and a relatively small volume of runoff. Because there is little or no warning time, the term “flash flood" is often used to describe thunderstorm floods. The average number of thunderstorm days per year in Colorado varies from less than 40 near the western boundary to over 70 in the mountains along the Front Range. The thunderstorm flood season in Colorado is from the middle of July through October. Notable events are:

Big Thompson Flood (1976) **-** The widely publicized Big Thompson Canyon flood disaster of July 31, 1976, was a result of an intense thunderstorm cell that dropped up to 10 inches of rain in a few hours over the basin.

1993 Floods **-** On May 15-16, 1993, a thunderstorm-induced flood event occurred at Rifle on Rifle and Government creeks. As is usually the case, the highest flows in the shortest period of time occurred when an estimated 125-year flood discharge impacted Rifle. Structures and vehicles in harm’s way suffered damages in excess of $200,000.

On June 17, 1993, a flash flood occurred on Shooks Run in Colorado Springs. Damages were confined to a mobile home park on the creek’s edge with losses estimated at $1 million.

In July 1993, the Town of Otis and the unincorporated area of Cope in Washington County and the City of Yuma in Yuma County experienced a weekend flood event as a result of three consecutive days of thunderstorms. Several homes suffered damages and roadways were inundated with loss in excess of $650,000. In Otis, a flood control and storm drainage project protecting the northern half of town worked.

On August 10, 1993 flash floods occurred on several creeks in Delta County. Two roads were washed out and a flood fight was conducted with sandbags on Robideaux Creek near the Department of Corrections Detention Facility.

On August 26-29, 1993 general rainstorms caused flooding in Archuleta and La Plata counties. A subdivision in Archuleta County was threatened and roads damaged as the Rio Blanco overflowed its banks south of Pagosa Springs. In Durango, the Fire Department had their emergency operations plan in effect and came very close to evacuating residents of a mobile home park on the Animas River.

1995 Floods - In the spring and early summer of 1995, the lower South Platte, the lower Arkansas and the Roaring Fork Rivers were impacted by significant flooding. Most damages were experienced by agricultural landowners.

1997 Floods - On July 24-28, 1997, the City of Fort Collins and most of eastern Colorado received soaking and/or drenching rains, adding to soil moisture in some locations. As the cold front arrived in the late afternoon of July 27th, strong thunderstorms developed just north and west of Fort Collins. Later that night, steady rains developed along the eastern base of the foothills in Larimer County and continued until about noon on July 28th. Several inches of new rain were reported just west and northwest of Fort Collins totally saturating the ground, producing major flooding in Laporte, and setting the stage for the evening flood event.

On the evening of July 28, 1997, intense rains began around 6:30 p.m. in the foothills west of Fort Collins. Winds from the east and southeast continued to pump moisture into the storm system throughout the evening. The core of the storm was very small but remained nearly stationary over the headwaters of Spring Creek, the Fairbrooke Channel, Clearview Channel, the CSU Drainage Basin, and the West Vine Drainage Basin. Rainfall intensity increased and reached a maximum between 8:30 p.m. and 10:00 p.m. before ending abruptly. A subsequent analysis of rainfall conducted by CSU showed a maximum of 10.2 inches of rainfall in less than five hours near the intersection of Drake Rd. and Overland Trail.

On July 29, 1997, slow-moving thunderstorms dumped large amounts of rainfall over the Pawnee Creek Basin in Weld and Logan counties and over the Schaefer Draw Basin in Morgan County north of Weldona. Floodwaters from Schaefer Draw entered the unincorporated Town of Weldona on the evening of July 29 while similar damaging floodwaters from Pawnee Creek entered the unincorporated Town of Atwood early July 30th (west of Sterling and north of U.S. Hwy 6). Additionally, floodwaters flowing east from Atwood entered the City of Sterling.

Figure 2.2 **COLORADO FLOOD FACTS**	
Counties/Cities/Towns with Flood Prone Areas	**268**
Population of 100-Year Floodplain	**250,000**
Homes in 100-Year Floodplain	**65,000**
Commercial/Industrial/Businesses in 100-year Floodplain	**15,000**
Total Value of Property in 100-Year Floodplain	**$11 Billion**
Cumulative Flood Losses from Turn of Century to 2003	**$5 Billion**
Source: CWCB	

Figure 2.3 **MAJOR FLOOD DAMAGES IN COLORADO**			
Date	**Major Stream or Location**	**Deaths**	**Damages (In 2003 $)**
May 1864	**Cherry Creek at Denver**	**?**	**$ 6,570,000**
July 1896	**Bear Creek at Morrison**	**27**	**6,570,000**
Oct. 1911	**San Juan River near Pagosa Springs**	**2**	**6,570,000**
July 1912	**Cherry Creek at Denver**	**2**	**131,400,000**
June 1921	**Arkansas River at Pueblo**	**78**	**832,200,000**
May 1935	**Monument Creek at Colorado Springs**	**18**	**56,940,000**
May 1935	**Kiowa Creek near Kiowa**	**9**	**16,425,000**
May 1942	**South Platte River Basin**	**?**	**9,307,500**
May 1955	**Purgatorie River at Trinidad**	**2**	**39,420,000**
June 1957	**Western Colorado**	**?**	**19,710,000**
June 1965*	**South Platte River at Denver**	**8**	**2,409,000,000**
June 1965*	**Arkansas River Basin**	**16**	**225,000,000**
May 1969*	**South Platte River Basin**	**0**	**23,542,000**
Sept. 1970*	**Southwest Colorado**	**0**	**14,454,000**
May 1973*	**South Platte River at Denver**	**10**	**425,736,000**
July 1976*	**Big Thompson River in Larimer County**	**144**	**93,294,000**
July 1982*	**Fall River at Estes Park**	**3**	**53,742,000**
June 1983	**North Central Counties**	**10**	**28,744,000**
May-June 1984*	**Western and Northwestern Counties**	**2**	**50,918,000**
May-June 1993	**Western Slope**	**0**	**2,343,000**
July 1997*	**Fort Collins & 13 Eastern Counties**	**6**	**318,995,000**
May-June 1999*	**Colorado Springs & 12 Eastern Counties**	**0**	**101,740,000**
July-Aug. 2001	**W. Colo., Greeley**	**0**	**4,350,000**
July-Aug. 2002	**Prowers Co., W. Colo.**	**0**	**1,890,000**
May 2003	**Eagle Co.**	**0**	**2,500,000**
TOTALS		352	$ 5,013,781,000
*** Presidential Disaster Declarations**			
Source: CWCB and Colorado OEM			

During the Presidential Declaration Incident Period (July 28 - August 12, 1997) storm systems drenched other areas in northeastern Colorado, as well as several counties in southeastern Colorado. In addition, the Denver Metro Area received flooding rains as did the Clear Creek County area to the west of Denver.

1999 - Flood Event Description - The three-day rainfall event occurred on April 29-May 1, 1999. Heavy rain and saturated soil caused flooding in two major areas along the Front Range: Northeastern Colorado along the South Platte River and some of its tributaries; and Southeastern Colorado along the Arkansas River and some of its tributaries.

Rainfall totals of up to 13 inches were recorded in the Cheyenne Mountain region of Colorado Springs. The La Junta region recorded approximately 8 inches over the same three-day period. The Arkansas River broke the dikes near North La Junta, flooding approximately 200 residences and businesses. The stormwater runoff from the three-day general rain resulted in large flood inundation and erosion in the Arkansas River and Fountain Creek watersheds. The preliminary discharge estimates, along with published FEMA 100-year flow values, are shown in **Figure 2.4**.

Figure 2.4 1999 FLOOD DISASTER STREAM DATA

River	Date	Discharge	Flood Stage	Crest
Fountain Creek @ Colorado Springs	April 30, 1999	9490 cfs	8 Feet	11.7 Feet
Fountain Creek @ Fountain	April 30, 1999	20,100 cfs	7 Feet	11.8 Feet
Fountain Creek @ Pueblo	May 1, 1999	18,900 cfs	10 Feet	12.5 Feet
Arkansas River @ Avondale	April 30, 1999	20,900 cfs	7 Feet	10.5 Feet
Arkansas River @ Fowler	May 1, 1999	?	9 Feet	11.3 Feet
Arkansas River @ La Junta	May 2, 1999	22,400 cfs	10 Feet	15.6 Feet
Arkansas River @ Las Animas	May 2, 1999	28,000 cfs	10 Feet	13.9 Feet
Source: FEMA Interagency Hazard Mitigation Team Report, July 1999				
Note: This flood was less than a 100-year recurrence event.				

These rainfall totals are large, but not extreme in comparison to the largest storms experienced in Colorado. What made this storm so different was that most of the affected basins were receiving heavy rainfall basinwide. This is not the "norm" for Colorado. Also, rain on snow is generally not a great problem in Colorado, but sizeable areas of the Front Range foothills did receive heavy rain on top of several inches of saturated snowpack. The melt rate of this snowpack was low, but additional water was added to the runoff.

The flooding that occurred along Fountain Creek and the Arkansas River was significant and will likely be considered the worst flooding event since *1965.* In total, the storm affected Bent, Crowley, Custer, Elbert, El Paso, Fremont, Kiowa, Larimer, Las Animas, Otero, Pueblo, and Weld Counties. These counties sustained damage to roads, bridges, culverts, homes, and business from overtopping, dike breaches, erosion, mudslides, and rockslides.

Snowmelt Floods

Snowmelt floods result from the melting of the winter snowpack in the high mountain areas. Snowmelt floods typically begin as spring runoff appears, after the first spring warming trend. If the trend continues up to 8-10 consecutive days in a basin where the snowpack has a water content more than about 150% of average, serious flooding can develop. The total duration of snowmelt floods is usually over a period of weeks rather than days. They yield a larger total volume in comparison to other varieties of floods in Colorado. Peak flows, however, are generally not as high as flows for the other types. A single cold day or cold front can interrupt a melting cycle causing the rising water to decline and stabilize until the cycle can begin again. Once snowmelt floods have peaked, the daily decreases are moderate, but fairly constant. Snowmelt flooding usually occurs in May, June, and early July.

Floods in June 1983, along the Cache la Poudre River in Fort Collins and Greeley, along Clear Creek and its tributaries in Silver Plume and Georgetown, and along the Arkansas River in Fremont and Chaffee counties were principally due to melting snow. The 1984 floods on the western slope were primarily snowmelt flooding.

Rain on Snowmelt Floods

Rain on snow flooding occurs most often in Colorado during the month of May. It is at this time of year that large general rainstorms occur over western Colorado. These rainstorms are most often caused when warm moist air from the Gulf of Mexico begins pushing far enough north that it begins to affect western weather. In combination with this movement of air mass is the continued possibility of cold fronts moving into Colorado from the Pacific Northwest. When these weather phenomena collide, long lasting general rainstorms can often occur. Rain on snowmelt exacerbates an already tenuous situation as snowmelt waters rush down heavily incised stream channels. Any abnormal increase in flow from other sources usually causes streams to leave their banks.

During the spring months of May and June when rivers are running high, there is a potential for flooding due to rain falling on melting snow. Usually such rain is over a small part of a basin, and the resulting flood is of short duration and may often go unnoticed in the lower reaches of a large drainage basin. To some extent, the cloud cover associated with the rain system can slow the melting cycle and offset the compound effect. In some cases, however, rainfall may be heavy and widespread enough to noticeably affect peak flows throughout the basin.

Flooding along the Colorado River in Grand Junction in July 1884, along Clear Creek at Georgetown in June 1965, and along the Gunnison and Colorado rivers at Grand Junction in June 1983, are examples of flooding from rain on melting snow. The effect of rain on melting snow in the Colorado River Basin in 1983 was felt as far downstream as Mexico. In 1984, rain or melting snow caused severe flooding conditions at Paonia.

On May 28, 1993, rain on snowmelt flooding occurred at Paonia on the North Fork of the Gunnison River. The rainfall occurred over a five-hour period during the evening. This caused the North Fork of the Gunnison River to reach its highest level since the 1984 flood season. Many miles of agriculture land experienced severe bank erosion in unincorporated Delta County.

Ice Jam Floods

Ice jam floods can occur by two phenomena. In the mountain floodplains during extended cold periods of 20 to 40 degrees below zero, the streams ice over. The channels are frozen solid and overbank flow occurs, which results in ice inundation in the floodplains. Ice jam floods can occur when frozen water in the upper reaches of a stream abruptly begins to melt due to warm Chinook winds. Blocks of ice floating downstream can become lodged at constrictions and form a jam. The jam can force water to be diverted from the stream channel causing a flood. An ice jam can also break up, suddenly causing a surge of water as the "reservoir" that was formed behind it is suddenly released. Ice jamming occurs in slow moving streams where prolonged periods of cold weather are experienced. Sometimes the ice jams are dynamited, allowing a controlled release of the backed up water to flow downstream. In 1955, 1962, and 1983, flooding in Rangely resulted from ice jams, as did 1973 flooding in Meeker, and 1980 in Gunnison.

Dam Failure Floods

Dam failure floods are primarily a result of hydrologic or structural deficiencies. The operation of a reservoir can also influence the safety of the structure.

Dam failure by hydrologic deficiency is a result of inadequate spillway capacity, which can cause a dam to be overtopped during large flows into the reservoir. Dam failure by hydrologic deficiency occurs from excessive runoff after unusually heavy precipitation in the basin. Large waves generated from landslides into a reservoir or the sudden inflow from upstream dam failures are other causes of dam failure by overtopping. Overtopping is especially dangerous for an earth dam because the down-rush of water over the crest will erode the dam face and, if continued long enough, will breach the dam embankment and release all the stored water suddenly into the downstream floodplain.

Examples of structural deficiencies include seepage through the embankment, piping along internal conduits, erosion, cracking, sliding, overturning rodent tunneling, or other weakness in the structure. Old age is often at the root of structural deficiencies. Seismic activity in Colorado has recently been recognized as a potential source of structural problems due to liquefaction of sand layers in the embankment of a dam.

The mechanics of a structural failure depends on the type of dam and the mode of failure. Dam failure floods due to structural deficiencies are characterized by a sudden rise in stream level and relatively short duration similar to a thunderstorm flood. They can occur at any time, but earthen dams appear to be most susceptible to structural failure during the fall and spring freezing and thawing cycles.

There are about 27,000 dams in Colorado, the majority of them being livestock water tanks, which

are small, low hazard dams located in rural areas. This number includes 1,829 jurisdictional-sized reservoir dams that are greater than 10 feet in vertical height, or have a reservoir whose surface area exceeds 20 acres, or its capacity exceeds 100 acre-feet. In addition there are several non-jurisdictional sized (NJ) reservoir dams that have been rated as Significant Hazard because of their potential impact on improved properties. The construction and repair of these non-jurisdictional sized dams must be approved by the State Engineer, and all the reservoir dams, including the Significant Hazard NJ dams, receive safety inspections periodically to assure they are being operated and maintained in a safe manner.

Although few lives have been lost from dam failures, property damage has been high. There have been at least 130 known dam failures and incidents in Colorado since 1890. The failure of the Lower Latham Reservoir Dam in 1973 and subsequent flooding in the Town of Kersey, Weld County, Colorado, resulted in a Presidential Major Disaster Declaration.

The earliest recorded dam failure flood in the Estes Park region occurred on May 25, 1951, when Lilly Lake Dam failed, sending flood waters down Fish Creek and into Lake Estes.

In June 1965, a flood occurred on Clay Creek in Prowers County, which overtopped an earthen dam being constructed by the Colorado Game, Fish, and Parks Commission. Although the dam did not fail, it did divert flood water into an adjacent drainage. The subsequent damage and death from this flood resulted in an important legal controversy known as the Barr Case. This case was finally decided in 1972 by the Colorado Supreme Court, which recognized the concept of probable maximum flood as a predictable and foreseeable standard for spillway design purposes.

The Lawn Lake Disaster of 1982 resulted from the failure of a privately-owned dam on Forest Service property, and $31 million of damage was sustained in Larimer County and Estes Park. A lawsuit awarded $480,000 to one of the four persons killed in the disaster. The most unusual flood from the failure of a manmade structure in Colorado is probably the complete draining of Lake Emma, a natural lake located high in the San Juan Mountains above Silverton, Colorado. On June 4, 1979, flood water flowed through a network of tunnels in an abandoned mine that extended under the lake.

The Carl Smith Reservoir failed on the evening of May 2, 1998. Carl Smith Dam is an 850 acre-foot, Class 1 offchannel reservoir in Leroux Creek Basin north of Hotchkiss, Colorado. The failure was a result of a large slide on the downstream slope that extended across the crest and into the upstream slope. The releasing water swiftly eroded down through the top half of the remaining embankment and quickly released about 500 acre-feet of storage. The peak discharge just below the dam was determined to be around 3,300 cfs. Several residences were evacuated. The only loss of life was livestock. The high water washed out numerous bridges, and diversion structures were quickly rebuilt to restore water to irrigators.

Historic Damages

Flood Damages

Compilations of exact data on the history of floods in Colorado since settlement began are lacking. The earliest known floods are reported to have occurred in 1826 in the Arkansas River and Republican River basins. Between 20 and 30 large magnitude floods (in terms of peak discharge) occur somewhere in Colorado every year.

The 25 most damaging floods in Colorado recorded history are listed in **Figure 2.3.** The most lives lost due to a single flood event occurred in the Big Thompson canyon on July 31, 1976, when 144 people were killed.

The most damaging flood in Colorado occurred in June 1965 on the South Platte River when almost $2.4 billion in damages (2003 dollars) was sustained in the Denver-metro area. Since the turn of the century, 352 people have been killed and over $5 billion (2003 dollars) in property damages have resulted.

All streams, regardless of size, have the potential to flood. In many parts of Colorado, spring brings the greatest threat of flooding because of additional water from melting snowpack.

The average annual loss in Colorado due to floods is $16 million. Between 1965 and 1999 the president declared nine major disasters in Colorado as a result of floods. Most of these disasters were caused by precipitation, but two were caused by dam failure. A summary of these Presidentially declared disasters are indicated in ***Figure 2-3***.

Mud and Debris Flow Damages

Mud and debris flow damages have been common throughout the history of modern man in Colorado.

Many of the older mountain communities were built in part or entirely on the sides of major mountain valleys which are the usual location of the debris fans of smaller tributary streams. A debris fan is the depositional land form produced by successive mud and debris flow deposits. The towns of Glenwood Springs, Ouray, Telluride, and Idaho Springs have a long history of damaging debris and mudflows. The Town of Marble in Gunnison County was nearly

destroyed by severe flows in the 1930s and 1940s, and the mining community of Brownville (near Silver Plume in Clear Creek County) was engulfed and destroyed by a series of flows in June 1912.

Much of the damage and loss of life during the Big Thompson storm and flood of 1976 was caused by multiple debris flows from smaller tributary streams. The 1965, 1969, and 1973 storm and flood events of the Front Range area produced extensive debris avalanching that originated on steep mesa side slopes of Douglas County. During the abnormally heavy spring snowmelt runoff of 1984 in Eagle County, the communities of Vail, Beaver Creek, and Redcliff were impacted by numerous debris flow events. In addition to threats to life and residential properties, the mud and debris flow events produce even more widespread effects on transportation and other public facilities, requiring extensive and costly clean-up and repair annually throughout Colorado.

Renewed development in mountainous areas of Colorado has increased dramatically in the past 30 years, driven by the demand for new resort communities and second homes. This pressure has led to a tremendous increase in development of lands vulnerable to severe to moderate mud and debris flow hazards. Identification and mitigation of existing hazards and future recognition of hazards in advance of land use decisions could save many lives and millions of dollars in property losses in the years ahead.

Damages in Colorado from debris flows and landslides are known to have amounted to several millions of dollars.

Catastrophic Landslide Damages

Catastrophic landslides capable of damming major streams have been relatively rare in Colorado during the historic period. The most serious example is probably the DeBeque Canyon slide of June 1924, which temporarily blocked the Colorado River and resulted in forced relocation of a small community, highway, and railroad.

Several other slides have or are encroaching on a stream but have not as yet advanced rapidly enough to cause serious backwater effects. However, there are hundreds of somewhat older inactive or semi-active slides in many areas of the state that could be reactivated or accelerated by increased ground moisture, stream erosion, man-made excavations or nearby earthquakes. There is particular concern that continued increase in soil moisture and snowmelt runoff as experienced in 1983 and 1984 could lead to reactivation of some of these slides, such as the one that occurred at Thistle, Utah, in 1983 with serious consequences.

Buffalo Creek Flood Event (1996) - In May 1996, a wildland fire burned about 12,000 acres of forested area in the Buffalo Creek vicinity. The fire burned intensely and quickly, leaving behind charred timber and a barren landscape devoid of vegetation and ground cover. The burned soils exhibited hydrophobic (water repelling) properties, and the burned area's natural erosion control and runoff inhibiting characteristics were altered by the fire. Those conditions, in conjunction with a heavy rainstorm on July 12, were the recipe for disaster in Buffalo Creek.

On the night of July 12, 1996, a thunderstorm occurred in the area of the community of Buffalo Creek, Colorado. The storm produced heavy precipitation over a short period of time. A flash flood occurred along Buffalo Creek, Sand Draw, Spring Gulch, the North Fork of the South Platte River (North Fork) below its confluence with Buffalo Creek, and several other tributary streams in the area. Two lives were lost as a direct result of the flooding. Roads, bridges, water lines, and other utility lines were damaged or destroyed. Numerous homes, outbuildings, and vehicles were damaged or destroyed, as well. A large quantity of sediment and debris was carried from the watershed and deposited along the affected stream reaches.

Although the geographic area affected was smaller than in some other floods, the July 12 Buffalo Creek flood event was truly a disaster. Other smaller scale floods have occurred in Buffalo Creek between June and September 1996, as well.

Peak discharges for the July 12 event for the North Fork, Buffalo Creek, Sand Draw, and other tributaries were estimated by the Colorado Water Conservation Board (CWCB) and the USGS. The CWCB obtained detailed surveyed cross-sections on the North Fork of the South Platte River, Sand Draw, and Buffalo Creek. The estimated flow rates on July 12 range from 4 to 25 times the published FEMA 100-year flow values. Obviously, the Buffalo Creek flash flood produced enormous flow magnitudes and was extremely dangerous.

1999 Landslide Events - Landslides occurred in several locations throughout the state due to heavy rains. El Paso County, and the cities within suffered damages from land movement. One project completed for DR-1276-CO included acquisition of structures damaged from land movement (Manitou Springs). In July 1999, several locations along Interstate 70 (I-70) were closed briefly due to land movements.

Risk Information

To reduce the community's vulnerability to hazards, some knowledge of the risk/threat must exist. Thus, hazards assessment has two important components:

1. ***Hazard Identification*** - What are the

hazards that pose a threat to the community or a particular segment of the population? What is their expected magnitude? How frequently could they be expected to occur? Where are they likely to occur?

2. ***Vulnerability Analysis*** - What is the risk from the threat? What are the likely impacts? What are the economic, social, and political ramifications of these impacts?

In most Colorado communities, substantial work has already been completed on a hazards assessment, and maps portraying these risks are readily available. This is an integral step in the emergency planning process. Hazards assessment is the foundation upon which the local Emergency Operations Plan (EOP) is built. It is also the foundation for hazard mitigation planning and floodplain management activities.

A hazards assessment provides the information that identifies the need to mitigate, as well as the ability to accurately focus mitigation efforts on a particular problem area. However, simply identifying vulnerability from an identified hazard does not guarantee that any action will be undertaken to mitigate that situation. Thus, a critical component necessary to mitigate the impacts of hazards is a determination of acceptable ***risk.*** When vulnerability to a hazard is determined to be at an acceptable level, mitigation activities are not pursued. However, when communities determine that the vulnerability and loss of assets is too great to chance (a determination of unacceptable risk), mitigation is pursued.

This concept of acceptable risk is central to the community's determination as to whether mitigation is undertaken or not. This determination is typically answered based on community values being combined with technical information. Hazard assessments allow communities to focus on hazard mitigation planning needs. However, implementation of mitigation measures will only occur following the public's acceptance of both the problem and the solution. This requires a determination that there is unacceptable risk.

To sum up, the hazard mitigation planning process begins with the five preliminary steps relating to hazards assessment. First, the hazards affecting the jurisdiction must be identified. Second, the community's vulnerability to those hazards must be determined. Third, a determination of whether that vulnerability constitutes an ***unacceptable risk*** must be made. Fourth, if an unacceptable risk exists, it must be communicated to those who are in the position to effect its change. Fifth, the people receiving this risk information must agree that the risk is unacceptable, that there are viable solutions to the problem, and that mitigation ought to be undertaken as a means of bringing about these solutions.

The term “hazard vulnerability” implies a relationship between human population concentrations and their respective potential for experiencing a hazard occurrence. Population expansion decreases available open space land area. The subsequent result is an increase in the probability that a Colorado community will sustain an impact from a hazard occurrence.

Hazard vulnerability is not new to the Colorado state and local emergency and floodplain management organizations. The risk of living in close proximity to potential hazards is well understood. Vulnerability to a hazard or multihazards can be reduced according to the degree of preparedness practiced and enjoyed by a community. Hazard mitigation is a process in which aspects of the natural and technological hazards on the population are reduced or eliminated.

Loss Potential

Loss potential in Colorado exists in 268 cities and towns. All 64 Colorado counties have floodplains. Over 250,000 people now live in Colorado’s floodplains. Flood loss potential estimates show that 65,000 homes and 15,000 commercial, industrial and business structures are in identified floodplains**.**

Total value of property, structure and contents at risk from the 100-year flood is now $12 billion (in 2003 dollars). Cumulative flood losses from the turn of the century damaging floods exceed $5 billion (2003 dollars).

In 1994, there were 9,893 flood insurance policies. In September 2003, there were 15,261 flood insurance policies statewide with an insured value of $2,477,325,600.

The Hazard Identification and Risk Assessment is located in the Umbrella Document of the State Natural Hazard Mitigation Plan.

Colorado Floodplain Management

Colorado is taking a proactive approach to floodplain management and loss reduction. Only a few communities with identified flood hazards are not enrolled in the National Flood Insurance Program. Floods in Colorado occur on an annual basis, impacting many communities. Flood losses happen due to existing development in the floodplain. Several Colorado communities that subscribed to Project Impact are seeing the benefits of their efforts when flood events do happen.

The Colorado Water Conservation Board manages

and implements Colorado's Map modernization Program and has a very active program for all Colorado communities.

3.0 Mitigation Activities Underway and Proposed

Existing Mitigation Plans, Programs, and Structures

Federal Government

The Federal Emergency Management Agency (FEMA) is an agency under the Department of Homeland Security, reporting to the President. Since its founding in 1979, FEMA's mission has been clear:

"To reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery."

State Government

Colorado Water Conservation Board (CWCB) - Flood Mitigation Assistance (FMA) Eligible Project(s) Grants

Pre-disaster flood mitigation planning and implementation funds are now available under two FEMA-funded programs. The Flood Mitigation Assistance (FMA) program and the Map Modernization program and both administered by the Colorado Water Conservation Board (CWCB). A list of the State's map priorities is shown in Figure 3.2 and is updated annually.

The CWCB also provides assistance to communities for their floodplain mapping needs through various programs.

Local Government Hazard Mitigation Plans

The Colorado Water Conservation Board (CWCB) is bringing the flood mitigation process to the local level where it has the greatest benefit. Each applicant for disaster relief assistance is asked to develop a flood hazard mitigation plan tailored specifically to the community. A suggested plan outline and a detailed questionnaire were developed by the CWCB to assist in this process.

The purpose of such a plan is to articulate those specific local issues which, if resolved, would help reduce future flood damages which will have an impact on the community. Those local issues, in turn, could also provide the basis for input to the statewide annual mitigation program review.

Several Colorado local governments have prepared hazard mitigation plans before and after flood events. (see **Figure 3.1** for a list of communities that have prepared plans.)

Local Government Flood Hazard Mitigation Plans

- **City of Manitou Springs**
- **Montrose County**
- **City of Boulder**
- **City of Arvada**
- **City of La Junta**
- **Otero County**
- **Prowers County**
- **Rio Blanco County**
- **Town of Basalt**
- **Town of Calhan**
- **Bent County**
- **Gunnison County**
- **Pitkin County**
- **Town of Wellington**
- **City of Delta**
- **San Luis Valley**
- **Town of Lyons**
- **Town of Jamestown**
- **City of Canon City**
- **City of Rifle**
- **City of Fort Collins**
- **City and County of Pueblo**
- **Town of Silver Plume**
- **Town of Georgetown**
- **Town of DeBeque**
- **Town of Wattenburg**
- **Participants in Northeast Colo. Region Plan**
- **Participants in Northern Colo. Regional Plan**
- **Participants in Upper Arkansas Area Plan**
- **Participants in DRCOG Plan**

Figure 3.1 (SOURCE: CWCB & DOLA WEBSITES)

Local Government Hazard Mitigation Projects

Hazard Mitigation Grant Program (HMGP) HMGP Projects DR-1186-CO:

The following are projects completed under HMGP DR-1176-CO in response to the 1997 flood event:

- **Fort Collins:** Completed a Stream Gauge/ Warning system and a flood proofing program.

- **Canon City:** This project included debris detention basins.

- **Larimer County:** Construction completed on a drainage/detention system in the West Vine area.

Figure 3.2
Colorado Floodplain Map Modernization
County Prioritization – March 2004

Priority	County	Population	Priority	County	Population
1	Douglas	**175,766**	**33**	Otero	**20,311**
2	El Paso	**516,929**	**34**	Montrose	**33,432**
3	Eagle	**41,659**	**35**	Gilpin	**4,757**
4	Larimer	**251,494**	**36**	Morgan	**27,171**
5	Garfield	**43,791**	**37**	Grand	**12,442**
6	Boulder	**291,288**	**38**	Custer	**3,503**
7	Weld	**180,936**	**39**	Alamosa	**14,966**
8	Mesa	**116,255**	**40**	Saguache	**5,917**
9	Jefferson	**527,056**	**41**	Prowers	**14,483**
10	Adams	**363,857**	**42**	Huerfano	**7,862**
11	Park	**14,523**	**43**	Hinsdale	**790**
12	Arapahoe	**487,967**	**44**	Las Animas	**15,207**
13	Elbert	**19,872**	**45**	Conejos	**8,400**
14	Pueblo	**141,472**	**46**	Rio Blanco	**5,986**
15	La Plata	**43,941**	**47**	Broomfield	**38,272**
16	Teller	**20,555**	**48**	Crowley	**5,518**
17	San Miguel	**6,594**	**49**	Dolores	**1,844**
18	Montezuma	**23,830**	**50**	Lincoln	**6,087**
19	Fremont	**46,145**	**51**	Moffat	**13,184**
20	Gunnison	**13,956**	**52**	Phillips	**4,480**
21	Mineral	**831**	**53**	Lake	**7,812**
22	Archuleta	**9,898**	**54**	Kit Carson	**8,011**
23	Ouray	**3,742**	**55**	Washington	**4,926**
24	Pitkin	**14,872**	**56**	Yuma	**9,841**
25	Delta	**27,834**	**57**	Sedgwick	**2,747**
26	Logan	**20,504**	**58**	Costilla	**3,663**
27	Summit	**23,548**	**59**	San Juan	**558**
28	Clear Creek	**9,322**	**60**	Bent	**5,998**
29	Routt	**19,690**	**61**	Cheyenne	**2,231**
30	Chaffee	**16,242**	**62**	Kiowa	**1,622**
31	Rio Grande	**12,413**	**63**	Baca	**4,517**
32	Denver	**554,636**	**64**	Jackson	**1,577**

• **Town of Crowley:** Flood proofing of the town hall (5% initiative funds)

• **Otero County:** Early warning flood emergency plan (5% initiative funds)

Hazard Mitigation Grant Program HMGP Projects DR-1276-CO in :

The following are projects completed under HMGP DR-1276-CO and Unmet Needs (see below) in response to the 1999 flood event:

- Otero County Acquisition Project (HMGP & UN)
- Manitou Springs Acquisition Project (HMGP & UN)
- La Junta Lift Station (UN)
- Ft. Collins Early Warning System (UN)
- Ft. Collins Flood Proofing (UN)
- Pueblo Early Warning System (UN)
- Colorado Springs Landslide Acquisition (UN)

The State of Colorado received additional funding through the **"Unmet Needs Program"** from the Federal Emergency Management Agency (FEMA) This money was used for additional projects and extensions of existing HMGP DR-1276-CO projects as indicated above which were not fully funded by the Hazard Mitigation Grant Program.

Hazard Mitigation Grant Program HMGP Projects DR-1374-CO:

The following are projects completed or inprogress under HMGP DR-1374-CO (winter storms of 2001) are:

- Yuma County (Eckley) tornado sirens
- Morgan County (Ft. Morgan) tornado sirens
- Town of Ellicott tornado shelter at school
- City of Delta ring dike at treatment plant
- Town of Georgetown channel improvement

PROJECTS FUNDED BY FMA

- City of La Junta Commercial Acquisition (1997)
- Town of Silver Plume Channel Improvement (1998)
- Prowers County Channel Improvement (1998)
- City of Ft. Collins Design of Flood Control Project (1998)
- Otero County Residential Acquisition (1998)
- Town of Silver Plume Residential Elevation (1999)
- Town of Jamestown Channel Improvement (2000)
- Town of Georgetown Channel Improvement (2000)
- Prowers County Channel Improvement (2001)

COLORADO MITIGATION ACCOMPLISHMENTS SINCE 1999

Governor's Conference on Flood and Drought: Conducted on December 2-3, 1999. This conference included local and national experts in drought and flood topics.

Colorado Flood Task Force: Is chaired by the Colorado Water Conservation Board. The task force meets in April and is active through "run off" season. It provides accurate technical information and advance measures to local governments. The task force includes participation by local, state, federal, and the private sector.

Safer Tomorrow Workshop: This is a partnership with the insurance industry and the Rocky Mountain Insurance Council. In 1999, OEM participated with the National Flood Insurance conference in Denver and a citizen/homeowner mitigation activity in El Paso county.

Community & Flood Mitigation Assistance Programs: Using FEMA funds, the Colorado Water Conservation Board (CWCB) manages the Community Assistance Program (CAP); statewide National Flood Insurance and Floodplain Management program; and Flood Mitigation Assistance (FMA) funding for projects to reduce losses on insured properties (elevate, buyout, relocate).

Project IMPACT: The goal of the FEMA Project Impact was to build disaster resistant communities. Recipients of Project Impact funds were The Cities of Ft. Collins and Delta, the Counties of Clear Creek, Morgan, and El Paso, and San Luis Valley. All communities have successfully completed the program.

CWCB Construction Fund: The fund provides planning, flood response assistance, and construction funds through a low interest loan program and limited grant funds.

CHAPTER 4 – IMPLEMTATION STRATEGIES

4.0 Implementation Strategies

Mitigation Opportunities

While similarities exist among the concepts of hazard mitigation, strong differences also exist among many of the strategies available to carry out these concepts. Warnings and land use application, such as floodplain regulations and acquisition of open space, are particularly cost-effective mitigation activities especially when compared to other available strategies, such as relief, insurance, and project measures. Effective land use, for example, can provide very high net benefits and can significantly lower future catastrophic loss potentials in a given community. Other adjustments, except warnings, generally cost more and yield the possibility for repeated catastrophic loss.

Although land use decisions are often controversial, when they are carefully planned and implemented, enormous savings in life and property can be realized in time. In Colorado, flood warning systems and effective land use decisions are implemented mainly by action at the local level. Therefore, this plan emphasizes mitigation activities that will essentially support local efforts.

Actions Organized by Goal

The following recommendations represent the collaborative efforts of Interagency Hazard Mitigation Team members and the Colorado State Hazard Mitigation Team, and they are intended to help achieve the goal of reducing future damage from hazards. Many of the recommendations can be implemented immediately; others must be viewed as long term measures. Recommendations are summarized and then more detailed recommendations follow. A concise explanation of the format used for the recommendations is shown below.

GOAL 1: Encourage the Use of Public Funds by State and Local Governments for Housing and Public Buildings in Non Hazardous Areas		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Seek ratification of State Executive Orders 8504, 8491 and legislation such as H.B. 1041 and incorporate into the Colorado Flood Hazard Mitigation Plan. In addition promulgate rules and regulations to administer the legislation if necessary.	**CWCB**	• Confirm governor's agreement • Contact by Governor's office with responsible state agencies with legislative sponsor and begin drafting bill • Perform updates to FHMP as warranted
Identify Long-Term Safe Affordable Housing Outside Hazard Areas Using Manufactured Housing Where Applicable and Volunteer Agency Construction	**DOLA**	• Contact local emergency managers to solicit involvement utilizing risk analysis in 1999 409 Plan, identify flood-safe areas in Colorado's NFIP communities
When rehabilitating structures in historic districts located in floodplains or other associated hazard areas, consider floodproofing, elevation, channelization or other techniques.	**CWCB** **FEMA**	Contact Colorado communities with historic districts and inform about mitigation grant programs and their opportunities
Work with the state Real Estate Services Division and State Buildings to ensure that facilities proposals and infrastructure take natural hazards into account when state projects are in the approval process.	**CWCB**	Review and comment on project proposals
Increase awareness of the designated 100-year floodplain in permitting new developments and structures	**CWCB**	Contact local floodplain and emergency manages and provide current information and technical data

GOAL 2: Promote Appropriate Land Use Decisions to Minimize the Vulnerability of Development to Floods		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Provide technical comments and recommendations on proposed state and federal legislation related to growth management.	**CWCB** **DOLA**	In Progress
Develop guidance and criteria for mapping and regulating mudflow/debris-flow areas.	**CWCB**	In Progress •Review CWCB guidance & criteria for traditional floodplain mapping •Establish work schedule to undertake mudflow/debris-flow guidance & criteria
Research and support the use of conservation easements, transferable development rights, cluster development, recreational uses, wildlife areas and open space uses as tools when undertaking mitigation initiatives.	**DOW** **CWCB**	In Progress •Gather information materials •Solicit input from states with similar programs/initiatives •Set schedule to develop guidance document
Optimize potential state and federal funding sources to support mitigation initiatives which are part of the Colorado Flood Hazard Mitigation Plan.	**OEM** **CWCB**	In Progress
Encourage use of watershed-based GIS maps in future land use planning and development review.	**CWCB** DWR	•Compile a current and sufficient volume of watershed-based GIS mapping information

GOAL 3: Educate the Public and Government Officials and Their Staffs About Flood Hazards and Mitigation		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Enhance the natural and beneficial functions of floodplains by promoting an increased awareness of wetland and habitat resources and their benefits to flood hazard mitigation.	**DOW** **CWCB** **DWR**	• Gather information materials • Set schedule to develop guidance document • Solicit input from states with similar initiatives
Provide flood hazard mitigation education for entities such as local water and wastewater management officials, local building officials, and road and bridge officials through state programs such as the FEMA-funded Community Assistance Program and other educational programs within state agencies such as the Division of Local Government (DLG) and the CWCB.	**CWCB** **OEM**	•Gather information materials •Set schedule to deliver workshops • Promote the public awareness of appropriate web sites and information

GOAL 3 (continued)		
Promote regional intergovernmental cooperation concerning watershed-based planning and floodplain management using a strategic planning process with goals and recommendations.	**CWCB** **OEM** **DWR**	•Contact local governments and determine level of interest •Gather informational materials •Set schedule to deliver strategic planning
Improve access to information regarding floodplain management, flood hazard mitigation and flood insurance through approaches such as the use of hyper-links between state agency websites, bibliographies of available materials, etc.	**CWCB** **OEM** **DWR**	• Post two public notices every March • Establish webmaster duties • Assign duties • gather information materials
Develop a hazard mitigation education program for public officials at annual conferences and workshops conducted by Colorado Association of Stormwater and Floodplain Managers (CASFM), Colorado Municipal League (CML), Colorado Counties Inc. (CCI), the Colorado Emergency Management Association (CEMA), the American Planning Association (APA), and the American Public Works Association (APWA)	**DNR** **CDOT**	• Establish webmaster duties • Assign duties • gather information materials
Through flood hazard reduction workshops, promote the use of a "hazard overlay" concept for GIS mapping using information developed by the Colorado Geological Survey (CGS) for Garfield County as a model.	**CGS** **CWCB** **OEM**	• Conduct statewide workshops
Promote public education on wildfire mitigation to reduce flood hazard potential in post-burn areas.	**CWCB**	• Gather informational materials • Publish articles in newsletters and releases
Provide newsletter articles, other relevant information on flood hazard mitigation and other forms of information exchange to professional organizations and local governments.	**OEM** **CWCB**	•Obtain agencies/entities PIO information
Develop a flood hazard awareness and education program utilizing programs already in place.	**OEM** **CWCB**	• Conduct workshops and provide educational materials
Promote the concept of people accepting fiscal responsibility for the consequences of living in floodprone areas.	**OEM, CWCB** **DNR** **DOLA**	• Provide education materials to local governments and the public.

GOAL 4: Identify Adverse Impacts to Public Health and the Environment and Encourage the Mitigation of These Impacts When Considering the Expenditure of Public Funds		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Promote: 1) the development of contingency plans for household hazardous materials, 2) anchoring/locating containers of hazardous materials, and 3) safely transporting these materials during flood events.	**CDPHE** **OEM**	• Develop educational program for local emergency personnel • Identify inventories of hazardous materials

GOAL 4 (continued)		
Encourage small communities to develop centralized sewer and water systems in areas that will not be impacted by flooding and relocate or floodproof existing treatment plants and/or lagoons, where possible.	**CWCB** **DOLA**	• Develop educational outreach program

GOAL 5: Encourage the Design and Engineering of Infrastructure to Take Into Consideration the Mitigation of Potential Natural Hazard Impacts		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Promote the design and operation of flood control systems and other related infrastructure to convey floodwaters safely.	**DWR** **CWCB**	• Establish section in state criteria manual
Promote the sustainability and access of critical infrastructure during disaster events to the 100-year flood event.	**OEM** **CWCB** **DWR** **CDOT** **DOLA**	• Develop educational outreach program.
Improve emergency warning systems and encourage the installation of additional sensors and reporting devices to improve high flow measurement capabilities along floodprone streams in high risk areas.	**OEM** **CWCB** **DWR**	• Activities in progress
Work with local emergency planners and floodplain administrators to identify critical infrastructure, housing, businesses and all other structures in the floodplains in their communities. Incorporate the information into local emergency response plans.	**OEM** **CWCB**	• Activities in progress
In floodplains that have already been urbanized, encourage and support a combination of structural and non-structural elements to reduce the risks from floods and other hazards.	**CWCB** **OEM**	• Begin formulating workshops at which this message is delivered

GOAL 6: Promote the Adoption of Model Codes and Standards (Such as the UBC and IBC) That Emphasize Hazard Mitigation and Reduced Use of Hazardous Areas for Development.		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Support the concept of communities using land use or construction permitting processes consistent with hazard reduction principles.	**OEM** **CWCB** DOLA	• In progress
Promote development of master drainage plans for state properties.	**CWCB** **OEM**	• Survey state institutions to determine existing criteria
Review the adequacy of existing stream gage networks and make recommendations for future maintenance and improvements.	**CWCB** **DWR**	• Inventory existing stream gage network and produce report • Annual improvements to selected stream gages

GOAL 7: Promote the Development of Flood Mitigation Plans.		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Promote the development of flood mitigation plans through the FMAP, PDM, and Flood Response programs.	**CWCB** **OEM**	• Conduct statewide workshops • Solicit applicants for planning grant funds • Encourage adoption of plans by communities
Maintain database of communities with approved plans.	**CWCB**	• Ongoing

GOAL 8: Publish Flood Documentation Report.		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Publish 14-day report of major flood events that presents the flood hydraulics and hydrology characteristics of the event and detail potential flood mitigation activites.	**CWCB** USACOE USGS	• Prepare field report
Publish annual report	**CWCB**	• Prepare comprehensive report covering major flood events • Document precipitation values, stream hydrology, inundation areas, and compilation of damages

GOAL 9: Modernize Current Floodplain Maps.		
Recommendation	**Lead Agency/ Partner Agencies**	**Action**
Digitize existing 100-year floodplain maps.	**CWCB**	• In Progress
Promote compatibility of Federal, State, and Local GIS capabilities..	**CWCB**	• In Progress
Create user-friendly floodplain map system through website design.	**CWCB**	• In Progress

CHAPTER 5 – PLAN IMPLEMENTATION AND MONITORING

5.0 Plan Implementation and Monitoring

Successful implementation of Colorado's Flood Hazard Mitigation Plan is the next step in the plan process. Both state and local involvement continue to be the foundation during the implementation and monitoring phases. The local emergency management offices and state level agencies will also play key roles in effective implementation and monitoring.

Governor's Office

The Governor's Office in coordination with OEM, DNR, CWCB, and other responsible state agencies, will initiate a memoranda of agreement with designated state agencies identified in the recommendation section of this plan to accomplish mitigation initiatives in Colorado.

The Office of Emergency Management (OEM) and Colorado Water Conservation Board (CWCB)

The Colorado Office of Emergency Management (OEM) and the Colorado Water Conservation Board (CWCB) will be responsible for coordinating the implementation and monitoring activities developed through the planning process and detailed in this plan document. They will involve the SHMT, other state agencies, county emergency management coordinators (EMCs), and other state and local level organizations.

In addition to the coordinator role, OEM and CWCB will develop and conduct education and outreach activities to introduce the plan to Coloradans. Activities will be targeted to specialized audiences: local level officials, state agencies, and policymakers. These audiences have been a part of the plan development and they will continue their participation through expanded awareness of their stake in its successful implementation. The purpose of this outreach is not to provide technical assistance, but rather to build a widespread understanding of the plan and the importance of mitigation.

The OEM State Hazard Mitigation Officer (SHMO) and the CWCB Community Assistance Program Coordinator will conduct coordination activities which will result in the implementation of this plan.

Role of State Hazard Mitigation Officer (SHMO) in Hazard Mitigation

In addition to the previously mentioned roles, The SHMO will activate the State Hazard Mitigation Team and serve as the chair of the team. The SHMO coordinates with the CWCB in the implementation of mitigation recommendations as determined in the Plan. Additionally, mitigation training materials are developed and utilized.

Role of Colorado Water Conservation Board (CWCB) in Hazard Mitigation

In addition to the above-mentioned activities of the CWCB, there are several duties and responsibilities of the Board which include:

- Continue to support the statewide association of local floodplain managers known as CASFM
- Work with other agencies in approving mitigation activities
- Assist in exploring a state funding pool exclusively for hazard mitigation
- Serve as communication liaison with regional FEMA personnel
- Assist in the implementation of cost-effective and environmentally-acceptable flood mitigation
- Provide technical assistance to county EMCs
- Visit each of the 64 counties on a five-year cycle, monitoring local project progress, as well as monitoring annual maintenance activities
- Develop training materials about mitigation
- Select digital area mapping for recovery operations

Role of Local Government Emergency Managers and Floodplain Coordinators

Local government emergency management and floodplain coordinators are frequently forced by multiple roles and job demands to deal with mitigation issues and projects. Throughout the mitigation planning process, the county EMCs and floodplain coordinators have played an important role. They are the local level contact and the coordinator of mitigation implementation, programs and activities. In that role, the county EMC is the key communication point between the state and local level and between local community agencies and organizations.

Local government emergency management coordinators and floodplain managers will assist in implementing this plan at the local level. Among their suggested actions are:

- Working closely and communicating with the OEM Regional Coordinator staff and the SHMO to implement mitigation

recommendations
- Conducting public awareness and education activities on mitigation, its importance and methods
- Conducting education activities for community organizations
- Developing and implementing the mitigation recommendations appropriate for the county
- Working with other community organizations and agencies on local mitigation projects
- Participating in regional and statewide cooperative mitigation efforts
- Identifying critical facilities and infrastructure at risk from hazards
- Monitoring progress in recommendation implementation through participation on a regional team

As the link between the CAP Coordinator, SHMO, and other community agencies and organizations, the county emergency management coordinator and floodplain manager is the recognized focal point for implementation and monitoring of mitigation activities at the local government level.

Monitoring & Reporting Activities

A simplified one-to-two page reporting form will be used by the designated lead agency to report to the Office of Emergency Management. OEM will monitor the implementation process as a whole at all levels to ensure that progress is being made.

The Office of Emergency Management and Colorado Water Conservation Board CAP coordinator will participate in onsite visits with a goal of reaching each of the Colorado counties over a five-year period. Not only will this give the state a first-hand look at the progress of mitigation implementation in the counties, but it will provide an opportunity for local level officials and the county EMCs to address needs, barriers, problems, and successes in their local mitigation efforts. The visits will be structured so that county EMCs and floodplain administrators are able to demonstrate their mitigation progress. This may also involve meeting with other local mitigation participants, such as the local utilities, county highway officials, or community organizations.

APPENDIX A – DEFINITIONS, ACRONYMS, & REFERENCES

44-CFR PART 9: Floodplain Management and Protection of Wetlands; regulations to implement and enforce Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands.

44-CFR PART 206: Federal Disaster Assistance for Disasters Declared On or After November 23, 1988; regulations for implementing the Stafford Act.

100-Year Discharge: is the volume rate of streamflow (usually expressed in cubic feet per second) having a 100-year frequency of recurrence. This discharge magnitude is based on statistical analysis of stream flow records and analysis of rainfall and runoff characteristics in a particular watershed.

100-Year Flood: (also called the Base Flood) is the flood having a one- percent chance of being equaled or exceeded in magnitude in any given year. Contrary to popular belief, it is not a flood occurring once every 100 years.

100-Year Floodplain: The area adjoining a river, stream, or watercourse covered by water in the event of a 100-year flood. (see 100-year Floodplain Schematic)

100-Year Frequency: means a recurrence interval averaging 100 years. It can also be stated as having a one- percent probability of occurring in any given year.

Assistance: Any form of Federal grant under section 404 to implement cost effective mitigation measures that will reduce the risk of future damage, hardship, loss, or suffering as a result of major disasters.

Base Flood: shall mean the flood having a one-percent chance of being equaled or exceeded in magnitude in any given year. (Also knows as the 100-Year Flood). This is the flooding event that is used to calculate flood risk for the National Flood Insurance Program (NFIP) and the Federal Emergency Management Agency (FEMA).

Base Flood Elevation: means the height (above sea level) that flood waters will reach at a given location in the event of the Base (100-year) flooding event.

Dam Safety - A program to inventory, classify and inspect dams to identify hazardous conditions and insure proper maintenance through corrective orders for the purpose of protecting human life and property. A dam (including the waters impounded by such dam) constitutes a threat to human life or property if it might be endangered by overtopping, seepage, settlement, erosion, sediment, cracking, earth movement, earthquakes, failure of bulkheads, flashboards, gates on conduits, or other conditions.

Emergency: - Any occasion or instance which, in the determination of the President, Federal assistance is needed to supplement state and local efforts and capabilities to save lives and protect property and public health and safety, or to lessen or avert the threat of a catastrophe in any part of the United States.

Executive Orders 11988 and 11990: The requirements to avoid direct or indirect support of floodplain development and to minimize harm to floodplains and wetlands. Federal decision-makers are obligated to comply with these orders, accomplished through an eight-step decision-making process.

Flood: means a general and temporary condition of partial or complete inundation of normally dry land areas from: (1) The overflow of inland or tidal waters. (2) The unusual and rapid accumulation of runoff of surface water from any source.

Flood Insurance Study (FIS): is an engineering study performed by FEMA to identify flood hazard areas, flood insurance risk zones, and other flood data in a community.

Flood Mitigation Assistance Program: A program created under the National Flood Insurance Reform Act of 1994 to provide mitigation planning and project grants to states and communities. The program is funded through flood insurance policy fees. A maximum of $20 million in grant money is available annually.

Floodplain: The lowland and relatively flat areas adjoining inland or coastal waters including, at a minimum, that area subject to a one percent or greater chance of flooding in any given year.

Floodplain Management: - A comprehensive approach "to reduce the damaging effects of floods, preserve and enhance natural values and provide for optimal use of land and water resources within the floodplain. Its goal is to strike a balance between the values obtainable from the use of floodplains and the potential losses to individuals and society arising from such use". The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to, emergency preparedness plans, flood control work, and floodplain management regulations.

Flood-proofing: Permanent or contingent measures applied to a structure and/or its contents that automatically prevent or provide resistance to damage from flooding by intentionally allowing water to enter the structure. Examples: Move all electrical outlets above expected flood levels; install floodwalls and protection closets around equipment, and secure furnace and water heater that cannot be relocated.

Floodway: means the channel of a river or watercourse and the adjacent land areas that must be reserved in order to discharge the 100-year flood without cumulatively increasing the water surface elevation more than one foot. Federal Hazard Mitigation Officer (FHMO): The FEMA employee responsible for representing the agency for each declaration in carrying out the overall responsibilities

for hazard mitigation and for Subpart M, including coordinating post-disaster hazard mitigation actions with other agencies of government at all levels.

Gauging Station: is a particular site on a stream, river, canal, lake or reservoir where systematic observations of gage height or discharge are collected.

Hazard Mitigation - A plan "to alleviate by softening and making less severe the effects of a major disaster or emergency and of future disasters in the affected areas, including reduction or avoidance". "Hazard mitigation can reduce the severity of the effects of flood emergency on people and property by reducing the cause or occurrence of the hazard; reducing exposure to the hazard; or reducing the effects through preparedness, response and recovery measures. Hazard mitigation is a management strategy in which current actions and expenditures to reduce the occurrence or severity of potential flood disasters are balanced with potential losses from future floods".

Hazard Mitigation Grant Program: A program authorized under Section 404 of the Stafford Act that provides funding for hazard mitigation projects that are cost effective and complement existing post-disaster mitigation programs and activities by providing funding for beneficial mitigation measures that are not funded through other programs.

Hazard Mitigation Plan: The plan resulting from a systematic evaluation of the nature and extent of vulnerability to the effects of natural hazards in a given area, that includes the actions needed to minimize future vulnerability to hazards. Section 409 of the Stafford Act requires that a hazard mitigation plan be developed (or an existing plan be updated) as a condition of receiving Federal disaster assistance.

Hazard Mitigation State Administrative Plan: The plan developed by the State to describe the procedures for administration of the Hazard Mitigation Grant Program.

Local Emergency Management Coordinator: The person appointed to coordinate emergency management activities for a county or municipal emergency management program.

Major Disaster: Any natural catastrophe (including any hurricane, tornado, storm, high-water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought), or, regardless of cause, any flood, fire, or explosion, in any part of the United States which in the determination of the President cause damage of sufficient severity and magnitude to warrant major disaster assistance under the Stafford Act to supplement the efforts and available resources of states, local governments, and disaster relief organizations in alleviating the damage, loss, hardship, or suffering caused thereby.

National Flood Insurance Program (NFIP): The program established in 1968 under the National Flood Insurance Act to provide property owners in floodplains with Federally subsidized flood insurance in those communities that implement ordinances to reduce future flood losses. The National Flood Insurance Reform Act of 1994 revised and strengthened many aspects of the program.

State Hazard Mitigation Officer (SHMO): The representative of state government who serves on the Hazard Mitigation Survey Team and/or Interagency Hazard Mitigation Team, and who is the primary point of contact with FEMA, other Federal agencies, and local units of government in the planning and implementation of post-disaster mitigation activities.

State Hazard Mitigation Team: The team composed of key state agency representatives and, as appropriate, local units of government and other public or private sector agencies, which is responsible for evaluating hazards, identifying strategies, coordinating resources, and implementing measures that will reduce the vulnerability of people and property to damage from hazards.

Zone A (Unnumbered): are Special Flood Hazard Areas subject to inundation from the 100-Year flood. Because detailed hydraulic analyses have not been performed, no base flood elevation or depths are shown. Mandatory flood insurance purchase requirements apply.

Zone AE and A1-30: are Special Flood Hazard Areas subject to inundation by the 100-Year flood determined in a Flood Insurance Study by detailed methods. Base flood elevations are shown within these zones. Mandatory flood insurance purchase requirements apply. (Zone AE is used on new and revised maps in place of Zones A1-30.)

Zone AH: are Special Flood Hazard Areas subject to inundation by 100-Year shallow flooding (usually areas of ponding) where average depths are between one and three feet. Base flood elevations derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements apply.

Zone AO: are Special Flood Hazard Areas subject to inundation by 100-Year shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet. Average flood depths derived from detailed hydraulic analyses are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone B, C, and X: are areas that have been identified in the community flood insurance study as areas of moderate or minimal hazard from principal source flood in the area. However, buildings in these zones could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. Flood Insurance is available in participating communities but is not required by regulation in these zones. (Zone X is used on new and revised maps in place of Zones B and C.)

Zone D: are unstudied areas where flood hazards are undetermined by flooding is possible. No mandatory flood insurance purchase requirements apply, but coverage is available in participating communities.

ACRONYMS

APA American Planning Association
ASCS Agricultural Stabilization and Conservation Service
BFE Base Flood Elevation
BLM Bureau of Land Management
BOR Bureau of Reclamation
CAP Community Assistance Program
CAV Community Assessment Visit
CCA Comprehensive Cooperative Agreement
CDBG Community Development Block Grants
CERCLA Comprehensive Environmental Response, Compensation, and
Liability Act
CFR Code of Federal Regulations
cfs Cubic feet per second
COE Corps of Engineers (Same as USACE)
CRS Community Rating System
DFO Disaster Field Office
DFS Department of Family Services
DH Department of Health
DOT Department of Transportation
DSR Damage Survey Reports
EDA Economic Development Administration
E.O. Executive Order
EOC Emergency Operations Center
EOP Emergency Operations Plan
EPA Environmental Protection Agency
FBFM Flood Boundary and Floodway Map
FCO Federal Coordinating Officer
FCIC Federal Crop Insurance Corporation
FEMA Federal Emergency Management Agency
FHBM Flood Hazard Boundary Map
FHWA Federal Highway Administration
FIA Flood Insurance Administration
FIRM Flood Insurance Rate Map
FIS Flood Insurance Study
FLB Farm Loan Board
FPM Floodplain Management
FSA Farm Service Agency
HAZMAT Hazardous Materials
HMA Hazard Mitigation Assistance
MCSAP Motor Carrier Safety Assistance Program MM
Modified Mercalli
NAD North American Datum
NFIP National Flood Insurance Program
NIIMS National Interagency Incident Management System
NOAA National Oceanic and Atmospheric Administration
NRCS Natural Resources Conservation Service
NWS National Weather Service
OCE Office, Corps of Engineer's
OSC On-scene Coordinator
P.L. Public Law
PEA Public Education and Awareness
PSC Public Service Commission
RCRA Resource Conservation and Recovery Act
SALEC State Law Enforcement Communications System
SAP State Assistance Program
SBA Small Business Administration
SCS Soil Conservation Service
SELS Severe Local Storms
SFHA Special Flood Hazard Areas
sq. ml. square miles
SHMO State Hazard Mitigation Officer
SHPO State Historic Preservation Officer
TSD Treatment, storage and disposal
USACE United States Army Corps of Engineers
USDA United States Department of Agriculture
USF&WS United States Fish & Wildlife Service
USGS United States Geological Survey, U.S. Department of Interior
WAPA Western Area Power Authority
WRDS Water Resources Data System
WSFO Weather Service Forecast Office
WYO Write Your Own

APPENDIX B - MITIGATION STRATEGIES

Introduction
There are basic strategies that may be applied to mitigate flood hazards. Each strategy has different measures that are appropriate for different conditions. In many communities, a different person may be responsible for each strategy. The strategies are described briefly below (see ***figure B-2)***.

Planning:
Through prevention, flood problems are kept from getting worse. The use and development of floodprone areas is limited through planning, land acquisition, or regulation. Building, zoning, planning, and/or code enforcement offices usually administer preventive measures.

Property protection:
Property owners on a building-by-building or parcel basis usually undertake property protection. Government agencies can provide information and technical or financial assistance to owners who want to elevate, floodproof, insure, or otherwise protect their property.

Emergency services:
Emergency measures are taken during a flood to minimize its impact These measures are the responsibility of city or county emergency management staff and the owners or operators of critical facilities.

Flood protection:
Keeping floodwaters away from an area with a levee, reservoir or other structural project is the goal of flood control. Flood control activities are usually designed by engineers and managed or maintained by public works staff.

Prevention
Prevention measures are designed to keep the problem from occurring or getting worse. They ensure that future development does not increase flood damage or they maintain the drainage system's capacity to carry away floodwaters.

Planning
Comprehensive plans and land use plans identify how a community should be developed. Generally, a plan has limited authority. It reflects what the community would like to see happen. Its utility is that it guides other local measures, such as capital improvement programs, zoning ordinances, and subdivision ordinances. The ordinances are covered in later sections.

A community's capital improvement program identifies where major public expenditures will be made over the next 5 to 20 years. Capital expenditures may include acquisition of land for public uses, such as parkland, and extension or improvement of roads and utilities.

If the community's long range plan calls for preserving the floodplain as open space, then the capital improvement program should support the plan by acquiring floodprone areas for parks and by not improving or extending roads into the floodplain.

Where appropriate: All communities that expect growth and are willing to guide it are prime candidates for developing land use plans.

Limitations: Plans are only as strong as the local authorities want them to be. To be effective, they must be implemented, which may require additional legal measures, such as a zoning ordinance.

For more information: Technical advice can be found at the county planning agencies.

Zoning
A zoning ordinance regulates development by dividing the community into zones or districts and setting development criteria for each district: There are two approaches that can prevent inappropriate floodprone development: separate districts and overlay zoning.

Separate districts: The floodplain can be designated as one or more separate zoning districts that only allow development that is not susceptible to damage by flooding. Appropriate districts include public use, conservation, agriculture, and cluster or planned unit developments that keep buildings out of the floodplain, wetlands, and other areas that are not appropriate for intensive development.

Overlay zoning adds special requirements in areas subject to flooding. The areas can be developed in accordance with the underlying zone, provided the flood protection requirements are met. As illustrated on the next page, there may also be setbacks or buffers to protect stream banks and shorelines or to preserve the natural functions of the channels and adjacent areas.

Where appropriate: Communities that expect development or redevelopment should adopt zoning ordinances.

Limitations: Some zoning regulations have been nullified because they placed too many restrictions on the use of private property and those restrictions could not be justified as needed for public health, safety or welfare. Some zoning requirements have been nullified when the community did not develop the technical data to support them.

Open Space Preservation

Keeping the floodplain open - free from development - is the best approach to preventing flood damage. Preserving open space is beneficial to the public in several ways. By preserving floodplains and natural sites for water storage, such as wetlands and low-lying areas, important recreational areas are secured while habitats for local flora and fauna are similarly protected.

Floodplains are excellent sites for scenic recreation areas and greenways. Local governments have prevented millions of dollars in flood damage through their open space preservation programs of floodprone areas. Open space preservation should not be limited to floodplains, as some sites in the watershed may be key to controlling runoff that adds to the flood problem.

Land use and capital improvement plans should identify areas to be preserved by acquisition and other means. Purchasing property with an easement, enables the land owner freedom to develop and use private property in the floodplain. If the owner agrees to not build on the floodprone parcel taxes are reduced. In some cases, the owner is allowed to develop the area for low hazard uses or to transfer the right to develop other flood-free parcels (known as **"TDR"** or transfer of development rights).

Easements do not always have to be purchased. Flood flow, drainage, or maintenance easements can be required of developers as a condition for approving the development. These are usually linear parcels along property lines or channels. Streamside property owners in return for a community channel maintenance program also can provide maintenance easements.

Where appropriate: Open space preservation is encouraged in undeveloped areas in floodplains, wetlands, other watershed storage areas, natural areas, and along streams and drainageways.

Limitations: Reaching agreement on an easement can be complicated. Enforcing it requires vigilance by the community.

For more information: Technical advice can be found at the county planning agencies and OEM. There may be funding programs to help acquire open space for recreational use or to preserve natural areas.

Floodplain Regulations

In addition to zoning ordinances, regulations on construction in floodplains are usually found in one or more of three locations: subdivision ordinance, building code, and/or a separate ***"stand alone"*** floodplain ordinance.

If the zoning for a site allows a structure to be built, then the applicable subdivision and building regulations will impose construction standards to protect buildings from flood damage and prevent the development from aggravating the flood problem.

Subdivision regulations: Subdivision regulations govern how land will be subdivided into individual lots, often requiring that every lot have a buildable area above flood level. These regulations set construction and location standards for the infrastructure provided by the developer, including roads, sidewalks, utility lines, storm sewers and drainage-ways. *(Storm sewer and drainage standards are discussed* in the *section on Stormwater management)*

Building codes: The building code should establish flood protection standards for all construction. These should include criteria to ensure that the foundation will withstand flood forces and that all portions of the building subject to damage are above, or otherwise protected from, flooding.

Some Colorado communities have adopted the Building Officials and Code Administrators' (BOCA) National Building Code. The 1997 edition sets standards for protecting foundations against flood damage, including requirements for soil testing and prepared fill.

Minimum regulatory requirements: Most communities with a flood problem in Colorado participate in the National Flood Insurance Program (NHP). The NFIP sets minimum requirements for participating communities' subdivision regulations and building codes. Communities are encouraged to adopt local ordinances, which are more stringent than the state or federal criteria. This is especially important in areas with older maps that may not reflect the current hazard. These could include prohibiting damage-prone uses (such as garages, sheds, parking lots and roadways) from the floodway or requiring structures to be elevated one or more feet above the base flood elevation.

Where appropriate: Any area with surface flooding is appropriate for floodplain regulations.

Limitations: As with any regulatory program, property owners may not be aware of the need for permits, or may resist getting permits, especially after a flood.

Because many existing floodplain maps are out of date, caution should be exercised when utilizing them for regulations. Conservative safety factors are highly recommended. Some of the requirements, such as floodway construction criteria or substantial improvement rules, can be technically complicated. However, assistance is available from FEMA, CWCB and OEM.

Flood Hazard Mitigation Measures

Figure B-2

Prevention	***Property Protection***
Planning	Building relocation
Zoning	Acquisition
Open space preservation	Building elevation
Floodplain regulations	Barriers
Wetland regulations	Dry floodproofing
Stormwater management	Wet floodproofing
Watershed measures	Sewer backup protection
Soil erosion and sediment control	Insurance
Channel maintenance	Community programs
Drainage protection	
Real estate disclosure	
Emergency Services	***Flood Control***
Flood threat recognition	Reservoirs
Flood warning Levees	Levees and floodwalls
Flood response	Diversions
Critical facilities	Conveyance improvements
Health and safety maintenance	Drainage/sewer improvements

Minimum Floodplain Regulation Requirements

Figure B-3

The National Flood Insurance Program (NFIP) is administered by the Federal Emergency Management Agency (FEMA). As a condition of making flood insurance available for their residents, Colorado communities agree to regulate new construction in the 100-year floodplain. To reduce confusion, the 100-year floodplain is called the "base floodplain" and the elevation of the 100-year flood is known as the base flood elevation."

The base floodplain is shown as the 'Special Flood Hazard Area" on the Flood Insurance Rate Map (FIRM) provided by FEMA. The base floodplain is designated as an "A" Zone. The 500-year floodplain is shown as a "B" Zone and areas above the 500-year flood level are shown as "C" Zones. On newer maps, the B and C zones are called 'X' zones. The designation as B, C, or X Zone does not mean that the area is not subject to local drainage problems or overbank flooding from streams or ditches smaller than the FEMA mapping criteria.

Additional floodplain regulatory requirements are set by state law. These are the minimum floodplain requirements. Cities and counties often have additional or more restrictive regulations.

1. All development must have a permit from the community. Development is defined as any man-made change to the land, including new buildings, improvements to buildings, filling, grading, mining, dredging, etc.

2. Only "appropriate uses" are allowed in the floodway. The floodway is the channel and central portion of floodplain that is needed to convey the base flood. Appropriate uses include flood control structures, recreational facilities, detached garages and accessory structures, floodproofing activities, and other minor alterations. They do not include buildings, building additions, fences, or storage of materials. The result of this requirement is that vacant floodways will essentially remain as open space, free of insurable buildings or other obstructions.

3. New buildings are allowed outside the floodway, but they must be protected from damage by the base flood. Residences must be elevated above the base flood elevation. Nonresidential buildings must be elevated or floodproofed.

4. When an addition, improvement or repair to an existing building is valued at more than 50% of the value of the original building, then it is considered a substantial improvement. A substantial improvement is treated as a new building.

5. Any filling, building or other obstruction placed in the floodplain reduces the amount of floodwater that can be stored. Developers must remove an equal or greater volume of fill to compensate for the loss of storage.

Wetland Protection Regulations

Wetlands are usually found in floodplains or depressional areas. They provide numerous natural and beneficial functions that warrant protection. Many wetlands in Colorado are subject to the Corps of Engineers' Section 404 regulations. Corps permits are required for projects that will place fill or dredged materials in a wetland. Before a permit is issued, the plans are reviewed by several agencies, including the US Fish and Wildlife Service and the US Environmental Protection Agency. Some communities also have their own wetland protection programs. Local programs are important for addressing gaps in the federal regulations, particularly for smaller wetlands and unregulated activities.

Where appropriate: Any community that seeks to preserve the natural and beneficial functions of wetlands should consider instituting wetland regulations.

Limitations: In many areas, smaller wetlands are not mapped, so projects may be built by owners who don't know the area should be protected. The Corps' authority is generally limited to filling wetlands. They can be impounded or otherwise damaged without a 404 permit being required. Therefore, communities should consider their own more comprehensive regulations.

For more Information: Technical advice can be found at the county stormwater planning agencies, the US Army Corps of Engineers, the US Fish and Wildlife Service, and the US Environmental Protection Agency.

Stormwater Management

Development outside a floodplain can contribute significantly to flooding problems. Runoff is increased when natural ground cover is replaced by urban development.

Unconstrained watershed development often will aggravate downstream flooding and overload tile community's drainage system. Effective stormwater management policies require developers to build detention basins and utilize other "best management practices" ("BMPs") to minimize increases in runoff rates and volumes in comparison to pre-development conditions.

Many developments utilize wet basins as landscaping amenities and for water quality BMPs. In some cases, watershed planners identify the most effective location for a basin. Communities then require developers to contribute funds for a regional basin in lieu of constructing on-site detention. Since detention only controls runoff rates, and not runoff volumes, there is a need for other BMPs to enhance the infiltration of stormwater. Swales, infiltration trenches, vegetative filter strips, and permeable paving blocks are recommended additions to the standard detention requirements. Stormwater management requirements are generally found in subdivision ordinances.

Where appropriate: Stormwater management requirements are encouraged for all new developments.

Limitations: The community must bear the cost of maintaining detention features after the developer leaves. Even with the best BMPs, development will increase runoff volumes.

For more information: Technical advice can be found at the county planning agencies, CWCB, OEM, and the Association of Flood and Stormwater Managers.

Watershed Measures

Agricultural practices also can cause stormwater problems. Subsurface drainage and row cropping can speed the runoff onto downstream properties. Because farmland is usually bare, stormwater runoff can carry large amounts of sediment that can fill in downstream drainage facilities.

Wetlands

- **Store large amounts of floodwaters**
- **Reduce flood velocities and erosion**
- **Filter water, making it cleaner for those downstream**
- **Provide habitat for species that cannot live or breed anywhere else**

Figure B-4

Ultimately, flood prevention must be viewed from a watershed perspective. Watershed measures should emphasize approaches that reduce runoff volumes and storing surface runoff naturally.

The runoff can be slowed down by watershed measures, such as vegetation, terraces, contour plowing and no-till farm practices. Slowing runoff on the way to a drainage channel increases infiltration into the soil and controls the loss of topsoil from erosion and the resulting sedimentation.

Protecting areas that naturally hold water is another effective type of watershed measure. Most watersheds have wetlands, depressions and other natural storage areas, which, if preserved from development, help reduce the impact of urbanization.

Where appropriate: Modifications to farming practices and urban development are most effective on steeper slopes where the most runoff and erosion occurs. Preserving storage areas is most effective in flat areas with natural depressions.

Limitations: These measures are usually implemented in areas beyond a municipality's jurisdiction. It can be hard to convince owners of property who are not near the flood problem to modify their drainage practices at their own expense.

For more information: Soil and Water Conservation Districts and their Natural Resources Conservation Service staff have both the expertise in watershed measures and the contacts with watershed landowners.

Soil Erosion and Sediment Control

As rain hits the ground - especially where there is bare dirt, as on farm fields and at construction sites - soil is picked up and washed downstream. This erosion of soil produces sedimentation in waterways that may be far from the eroded area. Sediment tends to settle where the river slows down and will gradually fill in the channel. Erosion and sediment control has two principal components: minimize erosion with vegetation and capture sediment before it leaves the site. Specific measures can be taken on farms and construction sites.

Farm practices such as contour plowing, terracing and no-till help reduce agricultural erosion and keep topsoil where it is needed. Soil loss can be cut at construction sites with techniques such as mulching, seeding, and erosion blankets. Silt fences and sediment traps slow runoff so sediment is dropped on-site before it gets to a watercourse. The key is to get these measures used, particularly on construction sites or at the downstream end of plowed fields.

Where appropriate: All watersheds are candidates for erosion and sediment control measures.

Limitations: As with any regulatory program, the community must have trained staff to educate developers and property owners, to monitor compliance, and to enforce the requirements.

For more information: Soil and Water Conservation Districts and their Natural Resources Conservation Service staff have both the expertise in watershed measures and the contacts with watershed landowners.

Channel Maintenance

Channel maintenance is an ongoing program to clean out blockages caused by overgrowth or debris. Public works or drainage districts crew usually does this work. Channel maintenance addresses vegetative growth and debris that can block flows. Channel maintenance activities normally do not affect the shape of the channel, but they do affect how well the channel can do its job.

Where appropriate: Smaller streams in all watersheds should be the targets of channel maintenance programs. Annual cleanup campaigns should be conducted in late fall through winter, before spring flows and when there are no leaves restricting visibility.

Limitations: If done improperly, channel clearing can allow bank erosion and destroy natural habitats. Channel inspection and maintenance must be conducted year-round. Property owners must consent to the maintenance program, in many cases, which may require legal negotiations to obtain maintenance easements.

For more information: Soil and Water Conservation Districts and their Natural Resources Conservation Service staff have both the expertise in watershed measures and the contacts with watershed landowners.

Drainage Protection

Small amounts of debris can accumulate or be accidentally or intentionally dumped into channels and detention basins. They obstruct low flows or accumulate to become major blockages. Stream dumping regulations are one approach to preventing intentional placement of trash or debris in watercourses.

Many communities have nuisance regulations that prohibit dumping garbage or other "objectionable waste" on public or private property. Some prohibit the discharge of polluted waters into natural outlets or storm sewers. Waterway dumping regulations need to also apply to "non-objectionable" materials, such as grass clippings or tree branches, which can kill ground cover or cause obstructions.

Many people do not realize the consequences of their actions. They may, for example, fill in the ditch in their front yard not realizing that it is needed to drain street runoff. Similarly, they may not understand how regrading their yard, or discarding leaves or branches in a watercourse can cause a problem.

Therefore, a drainage protection program should include public information materials that explain the reasons for the rules as well as the penalties. Regular inspections to catch violations also should be scheduled.

Where appropriate: All waterways, including street ditches, should be placed under stream dumping regulations. Obstructions have their greatest impact in smaller streams and ditches, so an anti-dumping program has its greatest effect there.

Limitations: Finding dumped materials is easy; locating the source of the refuse is hard. Usually the owner of property adjacent to a stream is responsible for keeping the stream clean. This may not be fair for sites near bridges and other public access points

For more Information: Example dumping ordinance language can be found in the NFIP Community Rating System - ***CRS Credit for Drainage System Maintenance***. Public information examples are in ***CRS Credit for Outreach Projects.***

Real Estate Disclosure

Many times after a flood, people say they would have taken steps to protect them-selves if only they had known they had purchased a floodprone property. Federal law requires that a potential purchaser of a parcel be told of any flood hazard.

Federal Law: Federally regulated lending institutions must advise applicants for a mortgage or other loan that is to be secured by an insurable building that the property is in a floodplain as shown on the Flood Insurance Rate Map. Because this requirement has to be met only five days before closing, often the applicant is already committed to purchasing the property when he or she first learns of the flood hazard.

This requirement does not affect renters or instances where properties are purchased without mortgages from federally regulated lenders. Enforcement of this law is up to the federal agencies that regulate lending institutions, such as the FDIC.

Where appropriate: Real estate disclosure can help everywhere.

Limitations: Enforcement of these regulations can be difficult. Compliance with the federal lending requirements has been spotty, but has been improving in recent years. The best approach for a community is to work with the local real estate agencies to encourage them to use the latest maps and provide assistance to them as needed.

For more Information: Information on the federal lending requirements can be obtained from the FEMA Region 8 Mitigation Division. The basic reference is ***Mandatory Purchase of Flood Insurance Guidelines.***

Property Protection

Property protection measures are used to modify buildings subject to flood damage rather than to keep floodwaters away. A community may find these to be inexpensive measures because often they are implemented by or cost shared with property owners. Many of the measures do not affect the buildings' appearance or use, making them particularly appropriates for historical sites and landmarks.

Building Relocation

Moving a building to higher ground is the surest and safest way to protect it from flooding. While almost any building can be moved, the cost goes up for heavier structures, such as those made of brick, and for large or irregularly shaped buildings. There are many experienced house movers in Colorado who know how to handle any job.

Where appropriate: Communities with areas subject to flash flooding, deep waters or other high hazard where the only safe approach is to remove the building should consider a relocation program.

Smaller, wood frame buildings on crawlspaces or basements are easier to move because they are lighter and it is easier to place jacking and moving equipment underneath the floor.

Relocation is also preferred for large lots with portions outside the floodplain or where the owner has a new flood-free lot available.

Limitations: Relocation can be expensive. The cost can average $25,000 and exceed *$50,000* depending on the type, weight and size of the house, whether it has to be cut and moved in parts, and the cost of a new lot. However, there are some government loans or grants available. Buildings that have suffered frequent flooding may be contaminated or structurally weakened and should be demolished.

For more Information: The following information is available from The Hazards Center in Boulder: ***Elevating or Relocating a House to Reduce Flood Damage, Design Manual for Retrofitting Flood-prone Residential Structures,*** **and** ***Protect Your Home from Flood Damage.***

Acquisition

Like relocation, acquisition ensures that buildings in a floodprone area will cease to be subject to damage. The major difference is that acquisition is undertaken by a government agency, so the cost is not borne by the property owner, and the land is converted to public use, such as a park.

Acquiring and clearing buildings from the floodplain is not only the best flood protection measure available, it is also a way to convert a problem area into a community asset and obtain environmental benefits.

Occasionally acquisition and relocation projects are undertaken jointly. The purchasing agency sells the building for salvage and the new owner relocates the structure rather than demolishes it.

Sometimes arrangements are made to allow the previous owner to buy back the building at the salvage value. This way, the owner gets to keep the house but have enough money from the sale to pay for a new lot and moving expenses.

Where appropriate: While acquisition works against any type of flood hazard, it is more cost-effective in areas subject to flash flooding, deep

waters, or other severe flood hazards where other property protection measures are not feasible.

Communities that want to clear floodprone areas, or redevelop them for other uses, such as recreation or riparian habitat, will find acquisition to be necessary. Acquisition, followed by demolition, is most appropriate for buildings that are too expensive to move -- such as larger, slab foundation, or masonry structures -- and for dilapidated structures that are not worth protecting.

Limitations: Cost is the number one concern with acquisition. An acquisition budget should be based on the median price of similar properties in the community, plus $10,000 to $20,000 for appraisals, abstracts, title opinions, relocation benefits and demolition.
Cost may be lower following a flood. For example, the community may have to pay only the difference between the full price of a property and the amount of the flood insurance claim received by the owner.

Communities should avoid creating a ***"checkerboard"*** acquisition pattern in which nonadjacent properties are acquired. This can occur when some owners, especially those who have and prefer a waterfront location, prove reluctant to leave. Creation of a checkerboard in a community simply adds to maintenance costs that taxpayers must support.

Smaller towns may be concerned if a large area is affected, for they may risk losing residents, businesses and/or revenue from property taxes and utility fees.

For more Information: The following information is available from The Hazards Center in Boulder: ***Elevating or Relocating a House to Reduce Flood Damage, Design Manual for Retrofitting Flood-prone Residential Structures,*** **and** ***Protect Your Home from Flood Damage.***

Building Elevation

Raising a house above the flood level is the best way to protect a structure that cannot be removed from the floodplain. Water flows under the building, causing no damage to the structure or its contents.

Raising a building above the flood level is cheaper than moving it, and can be less disruptive to a neighborhood. Commonly practiced in flood-prone areas nationwide, this protection technique is required by law for new and substantially damaged residences located in a floodplain. House moving contractors know the techniques to elevate a building.

Elevating a structure will change its appearance. If the needed degree of flood protection is low, the result is similar to putting a house on a two or three foot crawlspace. If the house is raised two feet, the front door would be three steps higher than before. If the house is raised eight feet, the lower area can be wet floodproofed for use as a garage and for storage of items not subject to flood damage.

Where appropriate: Smaller, wood frame buildings on crawlspaces are the cheapest to elevate. Use of this technique is safest where flood depths do not exceed six feet and velocities are slow.

Limitations: Elevation can be expensive. The price to raise a wood frame building on a crawlspace has run as low as $5,000 when the owner does much of the work. Otherwise, the cost averages $15,000 to $25,000. Raising a structure with brick walls resting on a slab foundation can cost *$25,000* to *$50,000.*

During flooding, the building may be isolated and without utilities, and therefore unusable. Newly created lower stories may be occupied or used for storage, putting household goods at risk for flood damage.

Some owners object to the change in appearance and are concerned that their home will stand out and affect property values.

For more Information: The following information is available from The Hazards Center in Boulder: ***Elevating or Relocating a House to Reduce Flood Damage, Design Manual for Retrofitting Flood-prone Residential Structures,*** **and** ***Protect Your Home from Flood Damage.***

Barriers

Barriers - levees, floodwalls and berms - keep floodwaters from reaching a building. Plans for using these structures must include ways to handle leaks, water seepage under the barrier and rainwater that accumulates inside the barrier. Therefore, they need a sump and/or drain tile to collect the internal ground and surface water, a pump to remove the water, and a pipe to send it over the barrier. Berms are commonly used in areas subject to shallow flooding. Not considered engineered structures, berms are made by regrading or filling an area.

Low floodwalls may be built around stairwells to protect the basement and lower floor of a split-level home. By keeping water away from the building walls, the problems of seepage and hydrostatic pressure are reduced.

The cost can range from practically nothing, when the homeowner re-grades the yard or builds a berm with local fill, to $10,000 for a concrete floodwall with drain tiles and sump pump.

Where appropriate: Barriers are recommended where the depth of flooding is three feet or less. Barriers may be used to protect any type of building, although buildings with basements wall be more

susceptible to underseepage. Floodwalls are more appropriate on small lots where there is little room for a levee. Care must be taken in locating barriers. They must be placed so as not to create flooding and/or drainage problems on neighboring properties. All barriers must be kept out of regulatory floodways.

Limitations: Private levees, floodwalls and berms are more susceptible to deterioration than publicly-held structures, as maintaining them falls to the property owner, not a public agency.

Private barriers do not eliminate the need for flood insurance, as they normally address only smaller, more frequent floods. They often have to rely on human intervention to close openings or operate pumps. Insurance is needed for those times when there is no one present who knows what to do when the flood arrives.

For more Information: The following information is available from The Hazards Center in Boulder: ***Design Manual for Retrofitting Flood-prone Residential Structures,*** **and** ***Protect Your Home from Flood Damage.***

Dry Floodproofing

Through dry floodproofing, a building is sealed against floodwaters. Buildings with crawlspaces generally are not dry floodproofed because water can seep under walls into the crawlspace. However, two kinds of structures can benefit from dry floodproofing.

Buildings on slab: All areas below the flood protection level are made watertight. Walls are coated with waterproofing compounds or plastic sheeting. Openings, such as doors, windows, sewer lines and vents, are closed either permanently, with removable shields, or with sandbags. Many dry floodproofed buildings cannot be distinguished from those that have not been modified.

Where appropriate: Dry floodproofing should be used only where the flood depth is less than three feet, and floodwaters will have little velocity. Most building walls and floors are not strong enough to withstand the hydrostatic pressure from more than three feet of water.

Buildings with basements: Houses with basements or other floors below grade can be protected with a backfill approach. A waterproofing compound is applied to the walls and fill is placed against the side of the house. The goal is to protect the house against contact with surface water or saturated ground. Such contact will greatly increase the amount of pressure against the basement walls, which may result in structural failure. Therefore, installation of a subsurface drain tile and one or two sump pumps is a must. Properly sized drains and pumps can handle any water that will naturally seep through the fill to reach the house.

Where appropriate: Buildings with basements or floors below grade may be dry floodproofed only with the waterproofing berm approach shown above and only where the flood protection level is lower than the first floor. In such a situation, the basement area should not be used as a bedroom where the occupants could be caught by surprise if water comes in.

Limitations: Dry floodproofing may involve closing openings and turning on pumps. These actions are dependent on adequate warning and the presence of someone who knows what to do.

As with barriers, flood insurance is highly recommended for those occasions when the protection level is overtopped or when there is no one available to take the proper steps.

An owner may be tempted to try to keep out floodwaters deeper than the design flood protection level. This can result in collapsed walls, buckled floors and danger to the occupants. It should be noted that floodplain management regulations do not allow new buildings to be dry floodproofed.

For more Information: The following information is available from The Hazards Center in Boulder: ***Design Manual for Retrofitting Flood-prone Residential Structures, and Protect Your Home from Flood Damage.*** Also, the Stormwater Floodplain Managers Association, CWCB, and OEM can offer technical assistance.

Wet Floodproofing

"Wet floodproofing" includes protection measures that deal with floodwaters in the building. Wet floodproofing approaches range from moving a few valuable items to rebuilding the flood prone area (see ***Figure B-9***).

Water standing on the ground outside a basement will quickly build up pressure against the basement walls, putting the equivalent pressure of six to seven feet of water on the walls and floor. Most wails and floors are not built to withstand hydrostatic pressure of more than three feet of water. As a result, sometimes basement walls and floors that have been waterproofed may be cracked, buckled or broken by the pressure of floodwater.
Wet floodproofing has one advantage over the other approaches: No matter how little is done, flood damage will be reduced. Simply moving furniture and electrical appliances out of the floodprone area can prevent thousands of dollars in damage.

Where appropriate: Wet floodproofing will work wherever there is an area above the flood protection level to which items can be relocated or temporarily stored.

Wet floodproofing works best in buildings with unfinished basements, garages, sheds, commercial and industrial facilities, and buildings with contents that are either water-resistant or easily moved. One-story houses are not appropriate for wet floodproofing because the likely flooded zone comprises living areas.

Many wet floodproofing techniques can be incorporated during repairs, reconstruction or remodeling. For example, damaged wallboard in a basement can be removed and the concrete wails can be covered with waterresistant paint. Wet floodproofing is sometimes the only way to protect a historic building that cannot be moved or elevated.

Limitations: Owners are often reluctant to "abandon" large areas of their buildings in anticipation of a flood. A plan to move contents relies on adequate warning and the presence of someone who knows what to do. Flood insurance is highly recommended for those occasions when the protection level is overtopped or when there is no one available to take the proper steps. There will still be a need for clean up, with its accompanying potential for health problems.

For more Information: The following information is available from The Hazards Center in Boulder: ***Design Manual for Retrofitting Flood-prone Residential Structures, and Protect Your Home from Flood Damage.*** Also, **CWCB and OEM can offer technical assistance.**

Sewer Backup Protection

In areas where sanitary and storm sewers are combined, basement flooding can be caused by stormwater overloading the system and backing up into the basement through the sanitary sewer line.

In areas where sanitary and storm waters are carried in separate pipes, the same thing can happen when there are cross connections between the storm and sanitary sewers or infiltration or inflow problems in the lines.

Houses which have downspouts, footing drain tile, and/or the sump pump connected to the sanitary sewer service may be inundated when heavy rains overload the system. If allowed by the local code, these should be disconnected. Rain and ground water should be directed out onto the ground, away from the building.

Four other approaches may be used to protect a structure against sewer backup: floor drain plug, floor drain standpipe, overhead sewer, and backup valve.

The first two devices keep water from flowing out of the lowest opening in the house, which is the floor drain. They cost less than $25. However, if the water gets deep enough in the sewer system, it can flow out of the next lowest opening in the basement, such as a toilet or laundry tub.

The latter two devices are more secure, but more expensive ($3,000 to $4,000). An overhead sewer, as illustrated on the next page, keeps water in the sewer line during a backup. A backup valve allows sewage to flow out while preventing backups from flowing into the house.

Where appropriate: All four approaches are appropriate for split levels, basements, and other locations where water in the sewer lines can back up into a building. Plugs and standpipes are only useful where the backup causes shallow flooding (lower than the next lower opening).

Limitations: Plugs and standpipes need to be carefully installed, as a little debris may prevent a good seal. In older houses, sewer lines under a basement floor may be clay tiles; a buildup of pressure may break them. Sewer lines in newer houses usually are cast iron, making breakage unlikely.

For more Information: The following information is available from The Hazards Center in Boulder: ***Design Manual for Retrofitting Flood-prone Residential Structures, and Protect Your Home from Flood Damage.*** Also, **OEM can offer technical assistance.**

In one city when flooding is imminent, firemen knock on the residents doors and say: "It is time to fill your basement" - The firemen lower the fire hose through the basement window and the homeowner turns on the nozzle and fills the basement with water to prevent hydrostatic pressure from collapsing the walls. Similar situations can occur in Colorado.
Figure D-8

Community Programs

Property owners usually implement their own property protection measures. Therefore, a community mitigation program should include measures to encourage and assist owners. A community's plan may provide three kinds of help: pertinent information, technical advice and financial assistance.

Information: A community has passive and active ways to inform residents about flood hazards and damage mitigation.

Passive ways to provide information, such as through references in the public library may not bring immediate reductions in flood damage.

However, they can have a long-term effect when people make construction or land use decisions later.

In addition to the library, many elementary and high schools have geography or science classes that are appropriate for sessions on flooding, natural hazards, and preserving the natural functions of floodplains and wetlands. The ***"Internet"*** is another source of information.

Active approaches include outreach projects, such as notices to floodprone property owners, to introduce the idea of property protection and identify sources of assistance. Other approaches, such as cable television shows, notices in public buildings, or booths at shopping centers, help but are not as effective as notices specifically directed to the owners of properties that should be protected.

More intensive efforts include distribution of handbooks and videos on property protection, public meetings with neighborhood groups, and "open houses." The last is a variation on the public meeting that includes exhibits by local contractors, insurance agents, building officials, the Red Cross, and others expert in flood protection who display their wares and answer questions.

Technical Assistance: In one-on-one sessions with property owners, community officials can provide advice and information on matters such as identifying flood hazards at the site, correcting local drainage problems, floodproofing, dealing with contractors, and funding.

Technical assistance can be given in telephone conversations, as complimentary critiques of the owner's plans or ideas, and in visits to the building. A more intensive effort is a written "flood audit," which provides the owner with a written description of the flood hazard at the site and specific recommendations to protect the site or building.

Where appropriate: Providing information and technical assistance can help every property owner, and is one of the least expensive measures a community can undertake. Every step taken by a property owner can reduce flood damages.

Limitations: Some community staff members are hesitant to provide advice due to a lack of knowledge about property protection measures or concern about liability should a recommended measure fail. Both of these concerns can be overcome through training using manuals, technical assistance, and courses available from FEMA and the Corps of Engineers.

For more information: Guidance on establishing a community program to provide information and technical assistance to property owners can be found in: *Flood Proofing Techniques, Programs* and *References, Local Flood Proofing Programs,* and *CRS* ***Credit for Public Information Programs.***

Low Cost Steps to Wet Floodproof a Structure

- Sewer openings, such as floor drains, must be plugged.
- Everything subject to damage by water or sediment must be moved to a higher level or out of the building. For example, the electrical panel and the furnace could be relocated to an upper floor.
- Where flooding is not expected to be deep, items needing protection may be placed on platforms or blocks.
- Owners should be prepared to move lighter items, such as lawn furniture or bicycles, after a flood warning is issued.

Figure B-9